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early air-breathing vertebrates than the mode of attachment of the ribs. No such difference as *Diplocaulus* presents is found anywhere among the members of the reptilian orders.

I by no means wish to suggest that *Diplocaulus* should be separated from the microsaurians as a distinct order, but that that group is entitled to a higher rank than that of a family I do believe. Furthermore, as I have said, *Crossotelos*, so far as the vertebræ are concerned, must be associated with *Diplocaulus*. If I am correct, however, in my recognition of the skull of this genus, it is of a widely different type from that of *Diplocaulus;* and the limb bones also, so far as I have determined them, are very different. The genus indeed represents a distinct family from Diplocaulidæ—the Crossotelidæ, further details of which I shall give in a future paper.

SOME NOTES ON THE OLYMPIC PENINSULA, WASHINGTON.

By ALBERT B. REAGAN, La Push, Wash.

INTRODUCTION AND ACKNOWLEDGMENTS.

THE field-work upon which this paper is based has been carried on as time would permit for the past four years, the most of the work being done during the summer months of each year. The type fossils collected are in the writer's collection at La Push, Wash., duplicates are to be found in the geological collections of the Leland Stanford Junior University and in the museum of the Kansas Academy of Science.

The Olympic peninsula is a very difficult region in which to do geological research work. There are but two wagon roads in the entire area west of Mount Olympus. One of these roads, aggregating some forty miles in total length, connects Port Angeles with Lake Crescent and Port Crescent, and the latter again with Lake Crescent; the other road extends from East Clallam, on the Strait of Juan de Fuca, south to La Push, of the Pacific front, a distance of about fifty miles. Trails extend along the beach of both ocean and strait. Trails also extend from West Clallam to Ozette lake and the Dickey lake country, and from the latter on to Quillayute Prairie. Another trail connects Forks with the Hoh country. A few short trails also branch off from the main trails here and there. These afford all the means of gaining access to the interior, except by canoe on the various streams; for off of the trails and roads the fallen timber, underbrush and ferns make the forest such a jungle in most places that one cannot travel half a mile an hour.

Consequently the stratigraphical work in the interior has been more of a reconnaisance; also, as a result, the division lines between the formations indicated on the map are merely suggestive.

In submitting this paper I wish to state that Dr. James Perrin Smith, professor of palæontology in Leland Stanford University, has had general supervision of the classifying of the fossils hereinafter described, and has also reviewed the manuscript for me. I also wish here to thank Dr. John Casper Branner, of Leland Stanford University, for the aid rendered me by him.

PREVIOUS LITERATURE.

So far as the writer is able to learn, the literature directly concerned with the geology and natural aspects of this region is confined to six papers.

Mr. S. C. Gilman,[1] a civil engineer, visited the central mountainous part of this region in 1895, of which he gives a fairly accurate map and a good general description.

Messrs. Dodwell and Rixon,[2] while making an expert forestry examination of the Olympic forest reserve, added some notes of interest to the geologist concerning the region.

Mr. H. S. Conrad,[3] in his article on "The Olympic Peninsula, Washington," gives some geological observations on the southwestern coast of the peninsula which are of interest.

Mr. Ralph Arnold visited the region in June and July, 1904, and has since published papers on "Coal in Clallam County, Washington,"[4] ' Gold Placers of the Northwestern Coast of Washington,"[5] and a "Geological Reconnaisance of the Coast of the Olympic Peninsula, Washington."[6]

Some observations on the geology of the islands off the coast of the peninsula are also included by Dr. W. L. Dawson in his article on "The Bird Colonies of the Olympiades."[7]

LOCATION.

The region here under consideration is in northwestern Washington. It covers an area of about 8000 square miles, or an area about the size of Rhode Island, Delaware and Connecticut combined. It extends approximately 100 miles in a north and south direction and 80 miles in an east and west line. It is bounded on the north by the Strait of Juan de Fuca, on the east by Puget Sound, on the south by Chehalis river and Gray's Harbor, and on the west by the Pacific Ocean. Port Townsend is at the northeast corner and Cape Flattery at the northwest, and the snow-capped Olympics occupy the central area. The region consists generally of a benched area along the coast from which the foot-hills gradually ascend toward Mount Olympus, 8150 feet in height, and the watershed between the Strait of Fuca and the Pacific, a high ridge which extends from the central mountain area to Cape Flattery. It embraces the whole of Jefferson and Clallam and portions of Mason and Chehalis counties. Port Townsend, Port Angeles, Neah Bay, and Cape Flattery on the strait, and Quillayute (La Push) and Gray's Harbor on the Pacific, are its most commonly heard of places.

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[1] S. C. Gilman: The Olympic Country. National Geographic Magazine, vol. 7, 1896, pp. 133-140, pl. 16.

[2] Arthur Dodwell and Theodore F. Rixon: Forest Conditions in the Olympic Forest Reserve, Washington. Professional paper, U. S. Geol. Surv., No. 7, 110 pages, 20 plates, 1 map. 1902.

[3] Science, N. S., vol. 21, No. 532, March 10, 1905, pp. 392-393.

[4] Contributions to Economic Geology for 1904. Bulletin No. 260, U. S. Geol. Surv., 1905, pp. 413-421.

[5] Ibid, pp. 154-157, fig. 11.

[6] Bulletin of the Geological Society of America, vol. 17, pp. 451-468, pls. 55-58.

[7] The Auk, vol. XXV, pp. 153-166, 1908.

HISTORY.

The railroad activity in northwestern Washington has brought before the public eye the Olympic peninsula with its giant timber and fertile valleys and prairies.

The region was first discovered by the Spaniards. In 1775 Bruno Heceta, a Spanish captain, landed on the coast a little south of the mouth of the Hoh river, planted the cross and took formal possession of the country for Spain. Then at the foot of the cross he had thus set up he buried a bottle sealed with wax, in which was written the record of his work and the statement that he took possession of the land for the crown of Spain. While he was thus in the official act of taking possession of the country, the Indians visited his ship, the "Sonora," under the lee of Destruction island, in charge of Heceta's companion, Bodega y Quadra. The Indians came in their canoes, held up bits of copper and iron, and with friendly signs sought to trade for more of the metals precious to them. Believing that everything was well, Quadra sent seven men ashore to trade with the Indians for wood and water. No sooner had they landed than 300 Indians rushed from ambush, killed the sailors, and tore the boat to pieces for the metal fastenings. Quadra was furious and wished to land thirty men to obtain revenge, but Heceta overruled him and sailed away, naming the island "Isla de Dolores," Isle of Sorrows. Later, in July, 1787, Captain Barclay, an English explorer, had a similar encounter with these same Indians, in which he lost six men. He named the river of Hoh "Destruction river" as a result of this encounter, but late geographers have restored the Indian name "Hoh" to the river, but retain the name "Destruction" for the island that Quadra named "Isla de Dolores."

On August 1, 1790, Alferez Quimper, having been sent to explore the Strait of Juan de Fuca by the Spanish Captain Elisa, discovered Neah Bay and Bahada Point, two miles further east. The former he named Bahia de Nunez Gaona. And in May, 1792, Lieut. Salvador Fidalgo established a military post at the place, with necessary buildings and fortifications, and remained there until September. The bricks of the old fort—bricks imported from Mexico in the "Princessa," can be found in the earth banks there to-day. Here the Spaniards came in contact with the British, under Vancouver. A conference was called, and Quadra failed to agree with the latter. Then the two commissioners agreed to send to their home governments for further instructions, as a result of which the Spaniards were compelled to abandon the country.

While Vancouver was maneuvering with Quadra for the possession of the North Pacific, our own Captain Gray was making his famous trip up the coast, staying the winter of 1791–'92 at the harbor that bears his name. As a result of his trip, and that of Lewis and Clark to the Columbia later, the country was jointly occupied by the British and the United States till the treaty of 1846 gave the Oregon territory to the United States. And later, in 1855–'59, Governor Stevens's treaties settled the Indian troubles. But actual settlement in the region did not begin till a later date, and at no time have there been many white people living in the region back of the Olympics except along the Strait of Fuca and in the few scattered prairies.

INDIANS OF THE REGION.

The explorers found a tribe of Indians occupying the valley of each stream that flowed out into the ocean or strait; the village of of the tribe being at the mouth of the respective stream. In addition, the Makahs occupied the Cape Flattery section of the peninsula and the Chemicums the Port Townsend division. The Indians lived principally by fishing, though they also hunted. They represented different linguistic stocks and were continually at war with each other. The wars were carried on principally for the purpose of capturing slaves. Besides the slaves, who were almost always cruelly treated, the people of each tribe were divided into the chieftain stock and the base people. The former owned the land and received the greater part of the benefits of the hunting expeditions and of the fish and whale catches. In fact the base people were considered only a little better than slaves.

These Indians are short and heavy set and resemble the Japanese very much in facial appearance. When discovered they had plural wives, the chief having the larger number of women. Marriage was a loose affair, from our standard. And it is not likely that Sodom and Gomorrah could have put them to shame so far as virtue was and is concerned. These simple-hearted people are worshipers of nature and of two imaginary beings—Duskia, a giantess, and Kwatte, the creator. Duskia represented evil; Kwatte the good. Duskia went about capturing and eating little children; Kwatte cleared the sea of the great sea-monsters that killed the fish and even came up on the land and swallowed up whole villages of people. At last good overcame evil: Kwatte killed Duskia. The Indians now confound Kwatte with Jesus Christ, calling him Jesus Man. At the present time the Indians have a religion of their own manufacture. It is a combination of the old worship and Christianity. They have a cross and candles. They self-hypnotize themselves. Then all shake, tremble, muscle-quiver, and stamp by the hour, as they chant the monotonous song: "Hi, hi, hi." By this they expect to gain entrance into heaven.

SCENERY.

The scenery of this region is grand. In the lowlands one sees and is engulfed in stately timber. And at the ocean beach one beholds nature in all its beauty. To ascend one of the numerous islands along the coast, say James island, at an elevation of 150 feet above the sea, on a still day, and look southward, one may discern the dim outlines of Destruction island with its precipitous coast and dangerous reefs; also the low sandy beach and rugged rocks of the mainland shore-line, which extends as far as the eye can reach; and added to the view is an almost impenetrable evergreen forest which covers the entire coast; while here and there can be seen curling upward from some settler's cabin a column of blue smoke. To the east one sees the white-robed, snow-capped Olympic mountains. To the west the whale and the salmon jump and play at the surface of the gently waving waters; and the ships of the world pass in sight to and fro. To ascend the elevated areas toward the Olympics the view broadens and becomes yet more sublime, while open, flower-bedded areas gradually take the place of the forest. From Mount Olympus to the east, across the busy "Sound region," there stand out boldly against the sky Mounts Rainier and Baker, while high mountains close in the horizon from the land of the Norman Lion on the north to where the waves have turned to stone on the south. To the west, beyond the wide expanse of green, the waters of the Pacific reflect the blazing rays of the setting sun. On every side everything is bathed in the most delicate tints and lies death-like in the evening haze, which seems to magnify them rather than subdue them.

VEGETATION.

The vegetation of the region is truly remarkable. Below 5000 feet is the great northwestern forest, which must be seen to be appreciated. Douglas fir, tide-land spruce and red cedar reach gigantic proportions. The available timber per township averages from 3000 feet (B M.) amid the high mountains up to 59,000 feet (B. M.) in the Quillayute region (Dodwell and Rixon). Below 2000 feet the region is a jungle. Taken as a whole it is the most heavily forested region in the country. There are estimated to be seventy billion feet (B. M.), in round numbers, or enough timber to supply the entire demand of the United States for two years.

The timber by species is as follows: Red fir, 24 per cent.; cedar. 10 per cent.; hemlock, 42 per cent.; spruce, 6 per cent.; Lovely fir. 18 per cent.

The principal trees and plants of the region are red elder, salal. *Shallon*, *Rubes*, *Ribes*, *Vaccinum*, Selaginella (*S. oregana*), bearded lichens, *usnea*, crab-apple, bearberry, dogwood (*Cornus nuttallii*).

Red fir (*Pseudotsuga taxifolia*): The principal forest-tree of the region west of the Olympics, it reaches its greatest development in the Quillayute country. It is seldom seen at elevations exceeding 3000 feet or near the seashore.

Lovely fir (*Abies amabilis*): A tall, silvery-barked tree found on the mountain slopes above 1500 feet.

Subalpine fir (*Abies lasiocarpa*): A tree found only near timber-line.

Red cedar (*Thuja plicata*): A tree growing in low and swampy lands. It is one of the principal forest-trees of the coast region.

Alaska cedar (*Chamaecyparis nootkatensis*): Found only on the mountain ridges.

Sitka spruce (*Picea sitchensis*): Found only in the vicinity of the Pacific coast.

Mertens hemlock (*Tsuga mertensiana*): A component of the forest everywhere up to timber-line.

Vine maple (*Acer circinatum*): A very common vine-like tree at altitudes below 2200 feet.

Maple (*Acer macrophyllum*): Found only on the bottom-lands. It makes a pretty shade-tree, and is used in making furniture.

Alder (*Alnus oregona*): Found along streams. The region where it grows makes good farm land when cleared. Alder makes the best wood, when dried, the peninsula can afford.

GAME.

In this region is to be found an abundance of game. Deer and elk are plentiful; wildcats, panthers and black bears are numerous; ducks and pheasants stay throughout the year, and the islands of the coast swarm with sea fowl; and the finest salmon and trout on the coast abound in the numerous streams.

CLIMATE.

The climate of this region is controlled by the prevailing westerly winds from the Pacific ocean, and is characterized by uniformity of temperature and by a heavy rainfall, the average being about 120 inches annually at Neah bay. Below 1000 feet elevation there is but little frost in winter, and snow is an exception. On the Pacific front ice is an almost unknown occurrence, while flowers bloom the year round and the grass keeps constantly green. The atmosphere is healthful, and the people are sturdy and strong.

SOIL.

The lower bottoms where alders grow are sandy; the bench bottom-lands are clay loam, but yield readily to cultivation. The soil of the swamps is a dark, porous vegetable mold from one to two feet in depth. This is underlaid with a substratum of blue clay, through which the surface-water cannot readily permeate. The hemlock uplands comprise about half of the general area, and where tested they have proven to be fairly productive. An analysis of the upland soil by Elton Fulmer, of the Washington State Agricultural College, gives the following:[8]

Unsoluble silica	54.8952
Hydrated silica	6 2524
Soluble	.2527
Iron oxid	5 3950
Phosphoric acid	.0895
Chlorin	.1026
Allumesia	8.3865
Lime	.2165
Magnesia	.2125
Potash	.0537
Soda	.4577
Sulfuric acid	.1479
Volatile and organic matter	14 9733
Moisture at 120	8 3567

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[8] The Leader, Beaver, Wash., December 25, 1896.

This analysis shows that the uplands are well adapted to farming and fruit-raising, and the settler has demonstrated it to be a fact.

The soil of the prairies is composed of decayed fern roots, ranging from one to three feet in thickness, the soil thus formed being a black loam. So far as the writer knows it has never been analyzed; but its richness is demonstrated by the large crops that the prairies annually produce.

In this region there is no such thing as a crop failure. Hay, oats, wheat, rye, potatoes, carrots, and rutabagas do well, and in the lower areas grass grows throughout the year. Dairying and stock-raising are the leading industries, though lumbering is largely carried on in the strait section.

HYDROGRAPHY.

Rivers.

The rivers have a radial arrangement, extending outward from the central mountain area somewhat like the spokes of a wagon-wheel. The watercourses on the sound and strait sides are short and torrent streams. Those on the Pacific front are much longer and larger. All of them will make fairly good logging streams and are also capable of being harnessed to run mills and electric plants. It is not unlikely, when the fall and volume of these streams are considered, that as much water-power can be developed in this region as in Maine and Rhode Island combined. The principal streams of the peninsula are: Dungeness, Elwah, Lyre, Pysht, Clallam and Hoko on the Strait of Fuca; and Ozette, Queets, Raft and Quillayute and its tributaries, Soleduck, Calawa, Bogachiel and Dickey on the Pacific front. Four of these streams—Dungeness, Elwa, Soleduck, and Calawa, have been officially measured, respectively, at Dungeness, at MacDonald, near Forks, and near Quillayute, with the results indicated in the following tables.[9]

The Elwah river rises in the Happy lake country, north of the central mountain area, and flows nearly north in direction to the Strait of Fuca. Throughout its course, except a very few miles of its length near its mouth, its fall is great. It is worthy of special mention here, from the fact that it is said to have cut its channel through granite walls in its upper middle course; this being the only granite so far mentioned in the region. This watercourse is also worthy of notice, from the fact that the upper Soleduck, or some other river flowing from the south crossing the present Soleduck, was once a tributary of this stream. This channel is now

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[9] U. S. Geol. Survey, An. Rep. 1900-1901, pt. IV, Hydrography, pp. 457-461.

ESTIMATED MONTHLY DISCHARGE OF DUNGENESS RIVER AT DUNGENESS, WASH.

[Drainage area, 145 square miles.]

MONTH, 1900.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth, inches.
January	1,144	392	667	41,012	4.60	5.30
February	392	280	306	16,994	2.11	2.19
March	3,784	235	866	53,248	5.98	6.89
April	1,336	392	667	39,689	4.60	5.13
May	1,024	430	678	41,689	4.68	5.39
June	1,912	568	918	54,625	6.33	7.06
July	808	520	611	37,569	4.21	4.85
August	544	268	359	22,074	2.48	2.86
September	280	218	244	14,519	1.68	1.87
October	568	213	311	19,123	2.14	2.47
November	496	235	281	16,721	1.94	2.17
December	3,928	373	1,194	73,416	8.23	9.49
The year	3,928	213	592	430,679	4.08	55.67

ESTIMATED MONTHLY DISCHARGE OF THE ELWAH RIVER AT McDONALD, WASH.

[Drainage area, 188 square miles.]

MONTH, 1900.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth, inches.
January	6,945	1,025	2,518	154,826	13.39	15.44
February	1,566	690	920	51,094	4.89	5.09
March	14,198	710	2,849	175,178	15.15	17.46
April	6,945	930	1,744	103,775	9.28	10.35
May	2,951	1,100	1,918	117,933	10.20	11.76
June	8,738	1,260	2,789	165,957	14.83	16.55
July	1,892	810	1,253	77,044	6.67	7.69
August	1,310	650	941	57,860	5.01	5.77
September	1,138	562	672	39,987	3.57	3.99
October	6,315	495	1,327	81,594	7.06	8.14
November	4,907	930	1,649	98,122	8.77	9.79
December	12,242	1,566	4,171	256,465	22.19	25.58
The year	14,198	495	1,896	1,379,835	10.08	137.61

ESTIMATED MONTHLY DISCHARGE OF THE CALAWA RIVER NEAR FORKS, WASH.

[Drainage area, 213 square miles.]

MONTH, 1900.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth, inches.
January	8,000	850	2,943	180,958	13.82	15.94
February	4,950	777	1,738	96,523	8.16	8.49
March	12,600	655	2,400	147,570	11.27	12.99
April	2,475	237	762	45,342	3.58	4.00
May	2,070	225	685	42,119	3.22	3.71
June	6,600	330	1,128	67,121	5.30	5.91
July	687	190	460	28,284	2.16	2.49
August	507	110	169	10,391	0.79	0.91
September	347	60	130	7,736	0.61	0.68
October	7,800	60	1,804	110,924	8.47	9.76
November	11,600	777	2,307	137,276	10.83	12.09
December	8,100	1,160	3,111	191,288	14.61	16.84
The year	11,600	60	1,470	1,065,532	6.90	93.81

ESTIMATED MONTHLY DISCHARGE OF SOLEDUCK RIVER NEAR QUILLAYUTE, WASH.

[Drainage area, 272 square miles.]

MONTH, 1900.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth, inches.
January	5,560	1,180	2,567	159,683	9.55	11.01
February	2,860	1,090	1,398	77,641	5.14	5.35
March	12,580	1,045	2,663	163,742	9.79	11.29
December, 22 to 31	....	....	4,419	87,650	16.25	6.04

blocked, but continuous from the Soleduck at Wineton through Crescent and Southerland lakes and Indian creek to the Elwah. The raising of the land of the peninsula on the side next the Strait of Juan de Fuca dammed the stream, thus causing the lakes and the wind gaps. Glaciation has also aided in this lake forming, as we shall see later. The Elwah has quite a delta at its mouth.

The Lyre river is the outlet of Lake Crescent. It has a great fall throughout its entire course, except just where it enters the Strait of Fuca. There it is forming a delta. Its course is along a fault. It seems to be a very young stream, the lake having its outlet formerly at its northeastern terminus by the way of Lake Southerland to the Elwah river.

Pysht river follows a fault a part of its course; the remainder of its course is through a broad synclinal trough. It rises on the divide between the Pacific and the Strait of Fuca near where the Clallam-La Push road crosses that mountain ridge and flows into Pysht bay of the Strait of Fuca. It has a very low lower course running back from the coast several miles, it having filled a bay here in recent times; and at the present time its silt is filling up the bay at its mouth at a very rapid rate, so that the bay is now a mud-flat at low tide. In the early days the town of Pysht on this bay was quite flourishing, but the filling of the bay became such a hindrance to navigation that the place was abandoned and East Clallam was made the depot for traffic with the interior region, though it has a much poorer natural road outlet into the interior region. The Pysht river flat is a fine farming section.

Clallam river rises in the highlands back of Clallam bay; flows to the east and then to the north, entering the east side of Clallam bay at East Clallam, following a fault line a considerable part of its course. It carries considerable silt. It is diked in its lower course so that it runs northward along the beach wall of the east side of the bay nearly to Slip Point, a distance of about three-fourths of a mile; this preventing it from being a hindrance to navigation.

Hoko river deserves notice from the fact that it rises on the south side of Clallam peak, makes a curve to the westward, turns northward, crosses the main divide between the Pacific and the Strait of Fuca, and enters the latter. It has kept pace with the rate of elevation and has maintained its channel. Its head waters are really in the Dickey-Quillayute valley, though by cutting a deep cañon through the ridge it has maintained its northerly course. This stream occupied its present position in Pliocene times, except that it flowed farther to the north in its lower course. It was this stream, aided probably by the Clallam river, that filled up the Clallam bay of that age. It is near base-level in its lower course; and its cañon serves as a pass from the Clallam bay region to the Quillayute country, via West Clallam.

The Sekiu is the last stream of any size that flows into the Strait of Fuca. In its lower course it cuts through fossiliferous beds of Miocene age.

Waatch river, on the Pacific side, is the first stream of any size south of the Cape. It is the remains of an abandoned strait that connected Neah bay with the ocean until even late Pleistocene times. It is now a mud-flat, its waters rising and falling with the tide.

The Tsoos (Sulz) river is a mud-tide flat in its lower course. It has a wide valley which joins the valley flat of the Waatch, the combined area being the farm lands of the Makah Indians.

Ozette river flows from the southwest corner of Ozette lake to the ocean through a very swampy area. It is a short stream without high banks and wholly cut in the Pleistocene deposits. It is of slow current, and fresh-water clams dot its bed. There is some talk of a ship canal being cut into this lake via this stream.

Quillayute river is formed by the union of the Soleduck and Bogachiel rivers about six miles from the ocean as the river runs. About a mile from the ocean it receives the Dickey river as a tributary from the northwest. It runs through a wide valley, most of which is material that has been deposited by the stream itself. A large bay has been filled up by this stream in comparatively recent times. It is a very changeable stream, and always carries great quantities of silt at flood times. Twenty-six years ago it entered Quillayute bay near the site of the Indian teacher's residence in the town of La Push, forming a large mud-flat at its mouth; but now it has cut its channel into the foaming surf three-fourths of a mile further up-stream. It now meets the incoming tide and is forming no delta, but a bar out at sea is seen to be forming. The muddied waters of the river color the ocean a mile from shore at flood time. The abandoned channel of the river at La Push is known as the "lagoon," and is the playground and highway of the village. Its connection with the ocean is closed, but it is still an arm of the river and its waters rise and fall with the tide. The Quillayute and its tributaries drain the greater part of the syncline that extends from the coast to the top of the divide between the Strait of Fuca and the Pacific and from the Happy lake country in the Olympics to Waatch strait, the Ozette lake and river occupying the western part of this same trough. It is a young stream. It is likely not older than the late Pleistocene, though its tributaries are much older, a bay having occupied its site till then. The tide extends up this stream between four and five miles. A rapids at its mouth prevents it from being navigable.

Dickey river, the western branch of the Quillayute, drains Dickey lake, and was likely once the outlet of Ozette lake, if the Quillayute did not itself flow through a part of it and Ozette lake to the sea. It is near base level throughout almost its entire course, has very low banks, and is dammed in its lower course with log jams. Its course, for the most part, is through Pleistocene deposits, and the country through which it runs is low and practically level. Its northern branch, however, has its channel incised in cemented rock, it rising near Clallam peak. At a couple of places on this stream water-power can be developed.

Soleduck river, the northern branch of the Quillayute from the east, rises near the Happy lake country and flows westward along and at the foot of the western extension of the Olympics to near Beaver, where it makes a bold bend to the southwest, which course it continues till it mingles its waters with those of the Bogachiel to form the master stream. In its upper course it is an old stream. In Pliocene times it flowed into a bay that then extended far up the Quillayute trough. In the late Pliocene it likely joined the other streams of the region and reached the sea beyond the present shore-line. Then in Pleistocene times it again flowed into an arm of the ocean that extended as far inland as Tyee, recent sea-shells being found embedded in the clays at this place. The lower channels of the respective streams of the Quillayute country were drowned at this time. This stream is capable of great power development. About two miles above the Sulphur Springs, in the Olympics, south of Port Angeles, there is a waterfall capable of developing 10,000 horse-power, which is to be developed in the near future for the purpose of running an electric road from Port Angeles via Crescent lake to the springs, and for lighting purposes along the line and at Port Angeles also. Besides the falls, the river has several rapids that may be utilized.

Calawa river, or Middle river, as the Indian word signifies, rises in the broken central region between the Soleduck and the Bogachiel and flows almost westward, pouring its waters into the Bogachiel a few miles above the latter's confluence with the Soleduck. In its lower course it is a meandering stream, though its channel is considerably incised. Once it entered the Bogachiel many miles above its present mouth, its abandoned channel now being Forks Prairie. A meander in it now is nearing the Soleduck, which stream will likely capture it in the near future of geologic time. Like the Soleduck, this stream has aided in filling up a bay in its lower course. In its upper course it is enclosed within cañon walls.

Bogachiel river, or Big river, as the Indian name signifies, rises within a mile of the head waters of the main branch of the Soleduck and takes a southwesterly direction, its course trending the southern rim of the synclinal trough. It soon encloses itself within cañon walls. Six miles from its course, as a bird flies, its bed is 2000 feet below the top of the surrounding ridges. In some places its inner valley is a half-mile or more in width; in other places it is "boxed up," and is further rendered impassable by rapids occurring in the river at these places. In the open spaces deer and elk feed. Reaching its middle course the stream turns westward, then west-northwest, and continues in that direction till it forms its confluence with the Soleduck. It is a very crooked stream, and is larger than the Soleduck and Calawa combined. In the rock walls of its cañon, in its middle course, there are exposed several seams of coal. In its lower course it has incised its channel in fossiliferous Pliocene rocks. It has several falls and is capable of great water-power development.

Hoh river has its head waters in the high ridges on the east side of Mount Olympus. From its source in makes a detour to the northward around the main mass of the Olympics in an almost semicircular course, then flows in a westerly direction to the Pacific, entering it in the vicinity of Destruction island, some eighteen miles down the coast from La Push. Into this stream drain the glaciers of Mounts Olympus, Meany and Constance; and the powdered sediment gives the water of the stream a milky color even at its mouth, forty miles from the mountains; a cup of water let settle has sediment in it that indicates that the mountain mass is mostly slates and schists, the former predominating. The river is large and will admit small schooners to enter it at high tide or at high-water times. Its course seems to be along a great fault, it trending the southern rim of the Quillayute synclinal trough, but on the outside, down-throw side of the uplift. In its lower course it runs through a wide, flat valley. In its middle course it cuts through a glacial bench, a benched area indicating that a halt was made by the Olympic glacier at this place as it was retreating to its mountain home at the close of glacial times. In its upper course the river is enclosed in almost impassable cañon walls 2000 to 3000 feet in height, though the cañon itself is wide. In the deep cañon thus formed the great blocks of ice, loosed from the snow-fields, plunge often with such terrific force that it shakes the immediate region as in an earthquake, the deep detonations caused by the impact being heard a distance of ten and even twenty miles, the noise at a distance of ten miles sounding like distant thunder.[10] The river is capable of developing a great deal of water-power.

Raft, Queets, and Quinaielt rivers drain synclinal troughs, the trough of the latter still being laked in its lower middle course. These streams are all characteristic for having their channels incised in Pliocene rocks in their respective lower courses.

Remarks.—As a closing remark on the rivers of the region, it is found that the streams flowing into the Strait of Fuca usually follow faults and the streams on the Pacific front drain synclinal troughs, the lower courses of the latter streams being drowned in Pliocene and again in Pleistocene times.

Lakes.

There are many lakes in the region. Some are high up in the mountains and are known as the Happy lakes and the Frozen lakes, the latter being so named because they are frozen over most of the year. These are beautiful in summer, and in time will be of value as reservoirs for watering stock. To-day only elk and deer drink of their waters and wallow in their muddy beaches. The large lakes of the region are Lakes Pleasant, Beaver, Sutherland, Crescent, Ozette and Dickey.

Lake Beaver is a small body of water on the Clallam-La Push wagon-road some eighteen miles from East Clallam. It is a very beautiful lake, enclosed within high, rocky walls. Its depression is caused by an upthrust of plutonic rock damming the channel of a little creek which now flows over falls and joins the Soleduck. If utilized these falls will furnish 1000 to 5000 horse-power for the running of mills, etc., depending upon the time of year. The position of the falls and the height of the lake (there are no signs of it ever having had a higher beach) seem to indicate that the plutonic dike which dams the stream is still being elevated. The lake is alive with trout of excellent flavor.

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[10] The Indians believe that in time of stormy weather a bird of monstrous size soars through the heavens and by the opening and shutting of his eyes it produces the lightning and by the flapping of its wings it produces the thunder and the mighty winds. This bird, they say, has its nest in a dark hole under the glacier at the foot of the Olympic glacial field and that its moving about in its home produces the "thunder-noise" there.

Pleasant lake is a little off of the road at the town of Tyee. It is a very small lake. It contains many trout and is a good "duck pond" in the fall of the year. It is due to the glacial damming of a small side stream of the Soleduck, the stream now flowing over the dam to the master stream. The lake once had an outlet farther to the northeast, but this has been silted up in recent times.

Lakes Sutherland and Crescent are in the east end of Clallam county. As we have seen, they are in a partially abandoned channel of a stream that once flowed from the south by the way of Wineton to join the Elwah. Indian creek is the remaining lower part of that stream. The laking is due to the differential uplifting of the bed of the stream in a former geological epoch accompanied by a sinking of the bed in the laked places The glacial drift also aided in this laking process. These lakes are seven and eighteen miles respectively from Port Angeles, and the latter is five miles from Port Crescent. Crescent lake is twenty square miles in area; Lake Sutherland twelve. They are both beautiful expanses of water surrounded by rocky walls, the walls surrounding Crescent lake being from 2000 to 3000 feet higher than the lake. This lake abounds in trout. It is now a summer resort, and cottages dot its shores wherever there is room for a cottage to be erected.[11] These lakes lie in the upper part of a synclinal trough, the northern end of which is truncated by the waters of the strait in the vicinity of Freshwater bay.

Lakes Dickey and Ozette lie in the western part of the Quillayute synclinal trough. They were protected from being filled by the northern glaciers that swept the region by Clallam Peak, which divided the glacier and caused it to pass around the present laked region with the greater bulk of its debris, filling the rest of the trough. Dickey lake is a very pretty expanse of water, covering several square miles in area. Ozette lake is one of the largest lakes in the state, being about thirty square miles in area. It lies near the Pacific coast, near the Indian village of the same name. It is very picturesque, and is dotted with several islands, one containing forty acres. This lake has an outlet now by way of the Ozette river to the Pacific; in former times its outlet seems to have been farther south down the coast in the vicinity of Yellow Banks, extending out from the south end of the lake. In the near future it will become a summer resort. Not only will it be valuable for that purpose, but various railroad companies are surveying it to the end of connecting it with the ocean by a locked canal, the latter being only a half a mile from the lake at its northern terminus. If this can be done, the lake will become an excellent harbor, and will add greatly to the commercial interests of the region.

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[11] The Quileute Indians have a myth about the origin of Crescent lake, as follows: "Once, in the valley which the lake now occupies, our people and the Clallams were having a big battle. For two days the people killed each other. Then Mount Stormking became enraged. You know the mountain that overlooks the north end of the lake from the east. Well, Mount Stormking got angry (all things on earth were living beings then) and he took a great piece of rock from his crest and hurled it down into the valley, killing all who were fighting and at the same time damming the stream with the great rock, so that it has been as it is now ever since, and no Indian has gone near the place since that day."

This myth causes the question to arise: Has there been volcanic activity in the region since the Indian occupation? Undoubtedly it was a volcanic region in Eocene times, but as yet evidence of later volcanic activity is wanting.

Medicinal Springs.

So far as the writer can learn, but two sets of medicinal springs are found in the peninsula, and all are hot springs. One set, numbering some three or four springs, was found last year near the head waters of the Elwah river. Since then a health resort has been established on the site. The other springs are on the Soleduck river, ten miles down-stream from its source and about twenty-five miles from the south end of Crescent lake as the trail runs. The springs, many in number, gush forth from a fissure in the earth's crust, which here runs in an east and west line for miles. It crosses the channel of the river in the vicinity of the present bath-houses and the springs are found on both sides of the river, though only those on the south side are developed. The hot springs are strongly sulfur; but associated with them are cold magnesia springs, though issuing from the side-walls and not from the fissure. These springs possess medicinal properties. Though the accommodations have always been poor and the only road a trail, many people visit the resort every year. A corporation has now obtained possession of them, a road is being built from the lake to them, and an up-to-date bath-house and a sanitarium are to be built in the near future. For people having rheumatism and kindred diseases there is probably no better resort in the state of Washington. In addition, the picturesqueness of the site adds to its value. The valley here is enclosed between ridges and peaks 1000 or more feet in elevation above the level of the river. On these roam the deer and elk, while two miles to the southward are open parks and beautiful lakelets, and a mile still further south is "Observation Point," from which those who desire to climb may see the surrounding country from the blue ice of the Olympic glaciers to the stormy capes at the entrance of the Strait of Fuca. But the question which particularly interests the geologist is why these springs are hot? It will be seen when the geological part of the article is discussed that in the Eocene epoch there was considerable volcanic activity in the region in the vicinity of Point Crescent and Freshwater bay and extending inland to the Crescent lake region. It therefore seems probable that, though primary volcanic activity has been non-active since that far-away time, secondary activity in the form of hot springs is still active, the earth's crust within still being hot near the surface here.

GLACIERS.

The glaciers of the region, except a few temporary ones of small area, lie in the depression on the northwest slope of the central mountain mass between Mounts Olympus and Constance, and cover some two townships in area when at their minimum size in August of each year. The ice mass seems to be several thousand feet in thickness, and in its downward movement is caused to project out far over the cañon walls of Glacier creek and Hoh river, leaving a dark hole-like space beneath it, the supposed home of the "Thunder bird," according to the Indian myths. A fissure loosens a great block of this snow-field now and then and it plunges to the bottom of the cañon, 2000 feet below, with a terrible crash. This glacier was very extensive in glacial times, reaching down the Hoh valley, even beyond the present shore-line, to Destruction island. Its retreat was slow, and a halt of long duration is now marked by a benched area in the middle section of that valley, the terminal moraine of the glacier at that time. There is also evidence that the glacier covered other faces of the mountain mass in the Glacial epoch. In recent times it has been reduced to a mere mountain cap. But few people have ever visited it, and of its surface appearance practically little is known.

THE PRAIRIES.

Large areas of open, untimbered, grass-covered lands are found in the mountainous portions, mostly upon the tops of the ridges, between elevations of 4000 and 6000 feet. They are scattered among the bunches of timber at timber-line. Their total area is about 250 square miles. In the near future grazing in these parts will no doubt become a profitable industry.

Besides the open grassy lands at timber-line, several prairies are found in the lower country west of the mountains. They are named as follows: Quillayute, Forks, Shuwah, Tyee, Beaver, and Oberg. In area they aggregate about 4000 acres. They have a black loamy soil of vegetable mold, and are extremely fertile. They were the first parts of the interior country settled, and are still the centers of population in that section. The cause of these treeless areas surrounded by an ocean of giant timber is somewhat a puzzle. They have rich black soil, which the rest of the region does not have. At first sight it would seem that likely they had been marshes, and had only recently been drained—so recently that the forest had not yet claimed them. This seems to explain the origin of Forks Prairie, at least in part, as there is evidence that it is the abandoned channel of the Calawa river; but it does not seem to be an explanation of the origin of the other prairies, as they are all high land. Quillayute prairie is on a bench, and Beaver prairie is on a semi-hillside, and there is no evidence of their having been marsh or swamp, the loam being composed of decayed ferns and fern roots. Another explanation suggests itself—that they were ponded areas in glacial times or the out-wash areas at points where glacial streams escaped from the ice-sheet; but the clayey composition of the subsoils would seem to show that none of these causes could have been the origin. Still another theory is that the black soil of the prairies is the deposits of sediments in lakes or swamps superimposed on the ice-sheet, and that at the melting of the ice at the close of the Glacial epoch, the sediment was dropped *in situ;* and that, being such rich soil, the ferns took possession of such area and have always kept the timber out by their rank growth. This would easily explain why the prairies are on high ground for the most part; but that the rank growth of ferns kept the forest from taking possession of the areas does not hold good; for a piece of land of any of the prairies let grow up to ferns will soon be taken possession of by young trees—in a few years a young forest—as has been demonstrated time and again in recent years.

Another theory, and one which seems to be a satisfactory explanation, is the following: It is noticeable that the prairies follow the river and are about a day's journey from each other for a canoe man. Also, the Indians fished and hunted throughout all this region formerly and their only highway was the river. Is it not possible that these prairies were the camping places of the aboriginees. And again, to strengthen this theory, the Indians dug fern roots from these prairie regions, dried them, and made them into a kind of flour which they made into a paste-bread. These roots they gathered both in the fall and in the spring. And at each gathering in the fall they burned the prairie over so they could find the roots easier, and also so that they could see the elk that would attempt to cross the open area ; for the ferns grew higher than a horse's back. Thus by this burning year by year, the prairies were extended. It would seem, therefore, that the treeless regions were first started as camping places, though originally some trees might have been blown down in each area by a storm ; and that they were enlarged year by year by the annual burning of the ferns. But an objection might be raised to this theory, that no tree-roots have ever been found in the prairies proper. This objection may be answered that since the first Indian occupation there has likely been a lapse of time sufficient for all roots of the then existing trees to decay, exposed to the elements as they would be. The black loam is the decayed fern roots that have accumulated in the countless years since the first fires destroyed the timber.

Some of the other prairies are Long prairie (600 acres), Gibson prairie (300 acres), and Sequim prairie (4000 acres). The latter is irrigated land and produces large crops. It is on the Puget Sound side of the Olympics.[12]

TOWNS AND HARBORS.

Gray's Harbor is a large, elongated, triangular-shaped expanse of water extending inland from the Pacific ocean, about sixty miles north of the mouth of the Columbia river. Its base is toward the ocean, from which it is separated by sandy spits. Its outlet to the sea is partly closed with sand in shallow water. The government has spent a million dollars or more in dredging this outlet so that large ocean liners may enter safely; but only partial success has been accomplished so far. Around the harbor have grown up sev-

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[12] Below are some Indian myths about the origin of these prairies, which, though not very scientific, may interest the reader. Myths used by permission of the Bureau of American Ethnology.

The Thunder bird and the myth about the origin of Beaver prairie at Beaver, Clallam county, Wash. (Police Hobucket):

"The Thunder bird lives in the heavens. He produces the lightning by his rapid flight through the air, the 'big noise' by the flapping of his wings. He feeds on the whale. Once he got a big whale in his talons and carried him to Beaver prairie and ate him there. The whale fought terribly hard before he was killed. So terrible was the fight that in the struggle the combatants killed all the timber in the vicinity and pulled up the trees by the roots. And no trees have ever grown on the site to this day."

The Thunder bird, the unsuccessful battle with the *Mimlos*-whale, and the origin of the prairies of the Olympic peninsula (Police Hobucket):

"At the time of the great flood the Thunder bird, the representative of good, fought the *Mimlos*-whale, the representative of evil. The great battle lasted for a long time. For a long time the battle seemed undecided. The powerful bird could not whip the beast in the water. Time and again it seized it in its talons and tried to fly with it to its nest in the mountains; but the powerful ocean monster would get away from it. Each time that it seized it there was a terrible battle, and the 'big noise' caused by the bird's flapping its wings (the thunder) shook the very mountains. The places where these fights occurred were stripped of their timber, the trees being torn out by their roots. A curse was brought upon them, and to this day no trees grow eral small towns and the cities of Aberdeen and Hoquium. And Mr. Hill has made it the terminus of one of his transcontinental railroads, and other roads are being headed towards it with a view of entering the Olympic country from that point. Lumbering is the principal industry of the region in the vicinity of the harbor, and here are located some of the largest lumber mills in the state of Washington.

Moclips is at the terminus of the northern extension of the railroads from Gray's Harbor. It has an excellent, open sandy beach. At the present time it is a summer resort.

La Push is the Indian village at the mouth of the Quillayute river. It is a picturesque place, and has a population of 231 Indians. From time immemorial it has been the home of the Quileute (or Quillayute)[14] Indians as it is to-day. At the present time it is governed by the teacher in charge of the United States Indian school located in the village. Were the Indian reservation thrown open, there is only one thing lacking to make this place a large town. That is a safe harbor. This it practically once had, at least for schooners, at the time the river entered Quillayute bay, but the change in the mouth of the river altered all this.

At the present time everything must be brought into the country over the road from East Clallam, on the Strait of Fuca, or on the sea by way of La Push. Most of the merchandise which is brought into the interior country comes by the way of Clallam bay. But little is brought by way of La Push, except such supplies as are brought for the K. O. Erickson-Taylor store at Mora, four miles from La Push—about three or four schooner loads a year; the schooner lies

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upon them. They are the prairies of the country. At last the whale escaped to the deep ocean, and the Thunder bird gave up the fight. That is why the *Mimlos*-whale or killer-whale still lives in the ocean to-day."

The Thunder bird and the origin of the Glacial Boulder-Train ridge across Beaver prairie (Police Hobucket):

"A man was living at Wo-lot (Beaver prairie). He was an elk hunter. He went off hunting very early one morning, but soon came back, saying that he had seen a very big bird sitting in a tree just a little way above the ground. This bird was the Thunder bird. That man took one feather from thunderer's wing. It was just as long as a canoe-paddle. He bent the feather and put it into his quiver and brought it home with him. After he had showed this feather to the people he said: 'I also saw a very, very large whale on the prairie. It had been carried there by the bird. The bird was resting, because he had such a big load.'

"The man sent word to all the Quileute people at the mouth of the river to come up and cut up the whale, because it was so large that the bird could not carry it further. All the beach and river Indians, three to six in each whaling canoe, came at once to the prairie to cut up the whale. On reaching there they found the huge whale lying dead at the lower end of the prairie, as had been reported. They immediately commenced measuring off the parts they wanted; one family took the head, another the saddle, and so on. By evening they had it all cut up. They piled up the block-like sections of the blubber all over the ground. Night came on; and the clouds overhead became black. The Thunder bird had been robbed of his prey and now he was returning with vengeance in his wings. It commenced to lightning and to shower a little, not so much at first. Then it hailed large hail, hail larger than your fist. The hail killed and mangled all the people on that prairie. The Indians had cooked and eaten whale meat that evening; and it was all right, it was good to eat. But after the storm both the meat and blubber were turned to stone; as were the people also. And to-day, in great blocks of rocks, they form a ridge from one end of the prairie to the other. One may even see the ribs of the whale's carcass and its massive head."

[14] Geographers spell the word "Quillayute." The Indian office spells it "Quileute."

at anchor in the harbor while the goods are brought ashore by Indians in Indian canoes. The cost of bringing in goods by way of Clallam bay is about twenty dollars per ton for the inland freight charges and five dollars per ton from Seattle to East Clallam. These rates keep imports down to the lowest limit and practically prohibit exporting.

If there were any easy means of exporting, it is probable that sawmills would be established at the mouth of the Quillayute river. As has been shown, there is an abundance of good timber in the country, and good sites for mills are to be found near the mouth of the river. Also, supplies from the outside world could be obtained more cheaply than at present.

A map of the Quillayute harbor and river, shown elsewhere, shows that the harbor is well sheltered on the northwest but open to the southwest storms, the prevailing storms in winter. Although the harbor is hemmed in by precipitous cliffs and high, rocky islands, it is itself entirely free from rocks. Its prevailing depth is twelve feet at low tide, 800 feet from the low-water line of the beach, and the bottom slopes regularly toward the ocean. At the entrance of the bay there is a general depth of six to seven fathoms. The mean range of the tide is about eight feet. The mouth of the river, as we have seen, was formerly at the north end of this bay; but about thirty years ago this mouth was silted up and the river formed a new mouth through a sand-spit three-fourths of a mile up the river from the old mouth. The width of this mouth varies according to the seasons. At the present time it is a little over fifty feet wide at low tide.

The bay into which the river now flows is rocky, exposed and dangerous, and there is a rapids in the river and a bar just off its mouth. No improvement of the present mouth is feasible. The improvement needed is the reopening of the old mouth of the river. The lagoon which formerly formed part of the river is separated from the ocean by a narrow sand-spit about 300 feet wide at high tide, and, having a maximum elevation of about twelve feet at low tide, the tide backs the river-water into the lagoon at high tide. This lagoon at the south end has a depth of four feet at mean low water, as referred to that datum in the ocean, but the actual depth is about eight feet, as the surface of the water in the lagoon is about four feet higher than the ocean when the tide is out, on account of the north end, the outlet of the lagoon, having been choked up with sand to a height of four feet above mean low water. To reopen the old mouth of the river it would be necessary to close the present mouth with a dike, to protect the sand-spit between the existing lagoon and the ocean, and to make a cut across the sand-spit to the south of the lagoon into the Quillayute harbor.

The estimated cost of this improvement is as follows:

Dike of piles, brush and stone, 1000 feet, at $5 per foot....	$5,000
Protection sill of brush and stone, 4400 feet, at $2 per foot..	8,800
Excavating cut across sand-spit..........................	3,200
Removing snags and other obstructions by blasting........	1,200
Engineering, superintendence, and contingencies, 10 per cent.,	1,820
Total..	$20,020

Or, in round numbers, $20,000.

In summer the river is low and does not carry much water. In the spring and fall, however, the water is high and the current rapid. The fall freshets are due to the heavy rains and the spring freshets to the melting of snow on the mountains. The river reaches its greatest height of about ten feet above low-water stage during the fall freshets, usually in November. It is probable that if the improvements as outlined above were made during the summer the fall freshets would scour out the channel through the lagoon and across the sand-spit into the Quillayute harbor, as the material at the north end of the lagoon would be readily moved by the current, and the sand-spit between the lagoon and the harbor would be easily scoured away.

The reopening of the old mouth of the river is the most practicable and feasible scheme of improving this river and harbor. An objection to this improvement is that the bay, though protected from the northwest storms, is exposed to the prevailing southwest winds of winter, and that heavy seas would break directly into the mouth of the river; but at such times the tides run high and the schooners could anchor in the river up from its mouth and be safe from the sweeping storms. Moreover, it would afford a safe outlet to any logs which might be cut and put in the river. Also, it would afford an opportunity to float sawed timber out on lighters to vessels which might be at anchor in the bay. [15]

Neah Bay was a possession of the Spaniards, as we have seen. For many centuries it has been the home of the Makah Indians, though they succeeded another race, likely the Quileutes. Near this village lives the Indian agent of the Neah Bay agency; and on an island opposite the Indian village there is being built the Pacific life-saving and wireless telegraph station. It has a good harbor but is exposed to the northwest storms. The building of a breakwater from the mainland northwest of the bay to the island on which the wireless telegraph station is being installed would make it safe. This likely will be done in the near future, as the channel is narrow and not very deep. A protected harbor should be located at this place, as it is the last harbor towards the ocean in the Strait of Fuca. This town in time will become the northwestern terminus of the Olympic peninsula railroads.

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[15] Partly after Capt. Harry Taylor, report on "Quillayute Harbor and River, Washington," August, 1897, under river and harbor act of June 3, 1896.

Both East Clallam and (West) Clallam are located on Clallam bay. They have tolerably good harbors and each of the two has quite a lumber trade. At the present time East Clallam has the interior trade of the Olympic region. West Clallam will be a terminus of a branch of the Olympic railroads.

Port Townsend is located at the northeastern corner of the peninsula. It has a protected deep-water harbor. It is a medium-sized city, though not so flourishing as before the rise of Seattle and Tacoma. It is a United States revenue station and near it is located one of the forts that guard the strait. It is also the county-seat of Jefferson county. It occupies a beautifully terraced position overlooking both the sound and the strait.

Dungeness was visited by Captain Gray in his famous trip nearly 130 years ago, and the old hull of one of his boats may be seen out on the Williams' ranch, three miles from town, where he had anchored in what was for many years afterward called Gray's marsh, a safe harbor for the anchorage of all boats at the time Gray visited the region, but now a fine farm. The first settlement at the place was made in 1852 by one John W. Dornell, who had come around the Horn from Maine in that year. He was a file-maker by trade. He built the first grist-mill in Clallam county, a mill run by wind power. For many years he was justice of the peace of the place, and had the honor of marrying the first couple ever legally married in the county, finishing the ceremony with the words: "What God and I have put together let no man tear asunder."

For many years Dungeness was the county-seat of the county, but in 1890 the county books and records were taken by force, it is alleged, and transferred to Port Angeles, which has been the official town of the county ever since.

This town is in the midst of a fine farming section and dairy country. It is situated on a beautiful bay and harbor that is well protected from the storms that sweep the straits. A narrow arm-like spit extends out from the mainland west of the city and curves up the strait, completely enclosing Dungeness bay except on the east side. The spit is remarkable for its having a secondary spit developed on its inner side. The spits are due to the strong tidal currents which flow through the adjoining straits at the rate of about five or six miles per hour, as is also the spit at Port Angeles, which will be mentioned later. The city they protect will grow as the country develops.

Port Angeles was discovered by the Spanish Captain Don Francisco Elisa. He had been tossed about for many weary days by storms and furious waves when suddenly he came upon a long, snake-like spit extending far out into the strait, curving so as to protect a large bay on its eastern side. In this bay Elisa took refuge; and in consequence of the safe and perfect harbor thus formed, he named it Port Angeles—"The Port of the Angels."

The narrow spit of land which encloses the bay-like harbor extends from the mainland shore north into the strait a distance of two miles. Then it gently curves to the east for nearly four miles, enclosing the large bay and leaving a broad, deep, wide, open roadway for the entering and going out of ships. And to make the harbor more perfect, it has a tenacious clay bottom, with no treacherous rocks to threaten the mariner seeking shelter within it.

In 1862 President Abraham Lincoln reserved a strip of land one mile deep and five miles long fronting this bay for a town site, amounting to 3520 acres. And the next year a small part of this reserve was sold in lots by the government at public auction. Then a short time afterward it became the seat of the United States customs office of the Puget Sound and straits country, but held it only a few years, when it was removed to Port Townsend. Then until 1890 the town was in a dormant state. But that year a boom came and the people made squatter town-site settlements all over the entire tract reserved by President Lincoln. Then they petitioned the government to throw the entire reserved town site open for settlement, which was done in 1894, Congress having appropriated $5000 to survey and appraise the land.

Now around the shores of this harbor is to be found the thriving city of Port Angeles. The site is unexcelled. Beginning with the bluffs overlooking the bay there is a gentle and continuous rise to the foot-hills, twelve miles away to the southward, above which tower the white-robed Olympics. Almost without exception every lot within the city limits commands a view of both the water and the mountains. Since 1890 it has been the county-seat of Clallam county.

GEOLOGY.

Introductory Remarks.

The high mountains form a circular area forty miles in diameter and 6000 to 8000 feet in height in the east central part of the peninsula. They are alpine in their central area, and are characterized by glacial sculpture, precipitous slopes, and high, barren ridges, with intervening prairie lands. From this central area, as has been stated, the streams radiate out toward the coast-line in all directions, the radial pattern being very perfect toward the coast region but less perfect in the mountain district. Along with the radial drainage-courses there also radiates outward from the central mass a system of ridges, the divides between the streams. Some of these ridges are due to erosive agencies. Many of them, however, are the result of uplift. Those along the Strait of Fuca are the upturned edges of fault blocks, the streams following the fault lines. Those radiating out toward the Pacific are anticlinal folds, the streams here occupying the synclines. These anticlinal folds jut out to sea as bold headlands, and still farther out as islands and reefs, and shallow-water areas known as "the banks." But to consider the region as a whole, the surface slopes gently seaward from an elevation of 5000 feet. The streams, therefore, seem to be consequent to some imaginary surface of double curvature. As will be noted later, neither volcanic debris nor Tertiary rocks have been found in the central mountain mass; nothing but upturned slates and sandstone and other rocks of pre-Tertiary age are found, and these pitched to a vertical position and the Tertiary of the lower country deposited upon their upturned, eroded edges. It would seem, therefore, that the radial drainage was initiated on the domed surface of a pene-plain.

Concerning the drainage of this region and its origin, Doctor Arnold says:[16]

> "The drainage of the region is radial, the radial pattern being very perfect about the borders of the high mountains, while within the mountains it is less perfect. The streams of the peninsula are arranged much like the spokes of a wheel, of which the region of the high mountains is the hub. This pattern could have one of three possible origins: First, the drainage was initiated on a volcanic accumulation about a center; second, the drainage was initiated on the domed surface of Tertiary strata, which has since been removed by erosion; third, the drainage was initiated on the domed surface of a pene-plain. By all of these hypotheses the streams are consequent to some imaginary surface of double curvature. The first is disproved by the absence of extensive volcanic material.

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[16] Bull. Geol. Soc. Am., vol. 17, pp. 454-455.

Choice between the second and third hypotheses is not wise at this time, but there are fewest difficulties in the acceptance of the third hypothesis, that the drainage results from the doming of a peneplain."

To turn to the coastal region, it is found to consist of an elevated terrace resting upon a wave-cut platform, which extends along practically the entire coast from Freshwater bay on the strait to Grandville on the Pacific. The terrace ranges from 50 to 300 feet in elevation, the average being about 150 feet. It is composed of more or less resistant rocks, except from Port Townsend to Freshwater bay; it is there composed of steep bluffs or more or less incoherent Pleistocene deposits and the two sand-spits previously mentioned. There are occasional stretches of the coast, however where the land slopes gradually down to the water-line, as, for ininstance, at the mouth of the Queets river and from Grandville to Gray's Harbor. Here the timber comes down to high-tide level, and the beaches are strewn with huge logs which have been undermined by the pounding tides and swept into the tumbling waters. Two ridges also face the water-front; the one between Crescent bay and Freshwater bay, the other between Pysht and Clallam rivers.

The terrace platform reaches its maximum width on the Pacific front where the gentle folds of the anticlines jut out to sea, the wave action being more intense on this side. The greatest width of this platform is about two miles, in the vicinity of the Flattery and Bodelteh islets at the mouth of the Ozette river, though a secondary platform extends out many miles further. The ridge here from which it is developed seems to be a monocline. On the primary platform are to be found islands in all stages of development, from partially isolated promontories to spike rocks and reefs. Destruction island, near the mouth of the Hoh river, and James island, at La Push, are the largest islands along the coast of Washington.[17]

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[17] An Indian myth of how the headlands and promontories of the Washington coast were formed (Elon Mason):

"It was long ago, when people were animals and animals were people. Kwatte was then still living on earth. He had his house on the beach near here; but he did not get hardly anything to eat, for the wolves of the region prowled the coast, caught all the salmon, ate all the berries, and devoured all of the animals of the woods, and gulped down all the fish eggs that floated ashore. What was Kwatte to do? One day the chief of the wolves came along up the coast. He came to Kwatte's house. Kwatte pretended to be sick. The wolf came in. He made himself at home. Kwatte let him stay. That night he made his bed at Kwatte's house beside Kwatte's fire. Soon he was sound asleep. When he had been asleep for a considerable time he began to snore. He snored loud. This was Kwatte's opportunity. He would now get even with the wolves; and he would also have some meat to eat. He got his knife; looked at it to see if it was good and sharp, then, finding it in good shape, he went to the mat on which the wolf was sleeping and severed his head with one blow. He then skinned the carcass and hung the skin up above the fireplace in his house to dry. Then he stored the meat safely under his bed. Then he went to sleep.

"The next morning, bright and early, a wolf came tracking his chief up the beach. He tracked him to Kwatte's house. He entered the house. Said he to Kwatte, 'Did you see Chief Wolf?' Kwatte answered, 'No, I am sick. I have not been out of my house. I have not seen him.' 'But, he came into your house. We tracked him here,' exclaimed the wolf. While wolf

The platform has an approximately horizontal surface, most of which is exposed at low tide. This is usually comparatively smooth, though occasionally large areas are covered with shingle rock, due to the platform truncating soft shale interbedded by occasional hard, thin layers of sandstone.

GEOLOGIC STRUCTURE.

"As indicated by the exposures along the coast, the structural lines in the region from Port Angeles to Gettysburg average approximately parallel to the trend of the Olympics, N. 70° W., S 70° E.; those in the Gettysburg-Clallam Bay territory almost perpendicular to this, or a little east of north, and those in the Clallam Bay-Cape Flattery stretch N. 30° W., S. 30° E., or again parallel with the ridges which extend along the coast in this region. A syncline, with its southern limb resting against the sandstones south of Lake Crescent and its northern one truncated by the waters of the Strait of Juan de Fuca, is the major structural feature of the Port Crescent-Gettysburg region. The Freshwater Bay coal-field is located in the northern portion of the trough of this syncline. A rather broad syncline, with its axis extending in a northeasterly-southwesterly direction, occupies most of the territory between Pysht river and Clallam Bay. The Clallam Bay coal-field occupies this synclinal trough. The region between Clallam Bay and Cape Flattery is formed by a great northeast-dipping monocline, the beds of which appear to have a total thickness of 15,000 feet."[19]

From the main ridge thus formed minor fault blocks extend out to the shore-line, on each of which the dip of the strata swings around from a northeast direction to a northerly, and in one case to even a northwesterly dip. The Bahada fault block is pitched northeast; the remaining fault blocks between Bahada Point and

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and Kwatte were talking, the wolf's slave, the blue jay, had gone over to Kwatte's fire to warm himself. As he was spreading his hands out before the fire, a drop of something fell on the upper surface of one of his hands. At once he perceived that it was a kind of oil. He smelled it. At once he recognized it to have the same smell as the smell of his master. He said nothing, but went out of the room. The oil had dropped from the skin that was drying. As soon as he was out in the yard the blue jay told all the wolves what he had discovered; many wolves had now followed the track to Kwatte's house. The blue jay was crying, mourning the death of his master. The wolves all rushed into the house. Kwatte had anticipated trouble, and had hung a basket of combs near the door. As the wolves entered he made a quick move, seized the basket of combs, and before the wolves could lay hands on him he sallied forth out the door past them and into the woods near by and then down the beach. The whole pack of wolves now followed him in hot pursuit. Time and time again they nearly overtook him. But as they were just in the act of seizing him he would take a comb out of the basket and drop it down on the beach in front of them, thus forming a point of land projecting from the mainland across the beach into the surging waves. The wolves, of course, were compelled to climb over the promontories thus formed. Many of them they climbed over; but finally they gave up the chase. But Kwatte kept on running till he had stood up all his combs on the beach.

"A long time afterward he came back, dressed himself in the dry wolf hide, and went to the house of the wolves and danced and sang before them, thus clad. And they dared not touch him, because of the wolf-skin dress that he wore." [18]

18. Used by permission of the Harrison Publishing Company.

19. (Arnold.) Bull. 260, U. S. Geol. Surv., p. 416.

the mouth of the Hoko river are pitched toward the northwest. Along each fault a small stream finds its way to the Strait of Fuca.

In the Cape Flattery promontory, which is separated from the rest of the highland area by a fault and by the Waatch river, the strata are much broken in the sandstone districts and contorted in the shaly sections, the shale looking much like it had been run through a giant crimping machine; but in a general way all the strata of this area from the strait to the Pacific dip north, varying from northeast to northwest. The higher angle of dip is on the Pacific side. It here reaches even sixty degrees. The promontory, therefore, forms one great monocline.

East of Waatch strait and south of the Clallam Bay-Cape Flattery monocline is the western extension of the axis of the Olympic mountains. This has been a line of disturbance, and consequently the structure is quite complex. South of this axis and extending eastward sixty miles is the wide synclinal Quillayute-Ozette trough. Then along the coast to the mouth of the Hoh river and extending from there to the Happy lake country, as we have seen, is a ridge which, from the mouth of the Hoh river westward, is narrow and roughly parallel with the main axis of the western extension of the Olympics, mentioned above. The dip of the strata is also north, varying from northeast to northwest. As a result of this change of dip, several determinable folds with northwest-southeast axis are formed, which now extend out as the headlands and rows of islands off the coast. Folds and intervening synclines are also noticeable south of the Hoh river, all with axis parallel to the ones previously mentioned. In the vicinity of the mouth of the Quinaielt there is a prominent syncline developed in the Pliocene (Arnold).

FORMATIONS IN DETAIL.

GEOLOGIC FORMATIONS.—The formations of this region, so far as known, are as follows: Supposed pre-Cretaceous, supposed Cretaceous (tree stages), Eocene, Oligocene-Miocene, Pliocene (two stages), Pleistocene, and recent.

Supposed pre-Cretaceous.—Rocks supposed to be pre-Cretaceous in age are found in the central Olympic region(?) (not mapped); in the central ridge which extends westward from the Olympics to Cape Flattery(?) (mapped where known to occur as surface rock); and on the Pacific front at Portage Head, eight miles south of Cape Flattery, and at the Point of the Arches, four miles further south. and in the region from Point Granville south to within a few miles of Gray's Harbor, and a few other smaller exposures along the

Pacific shore-line. So far no rocks of this age have been found on the north slope of the peninsula.

In speaking of the rock structure Professor Gilman says:[20]

"The country rocks of the mountains are syenite, gneiss, quartzite, protogene, crystalline and chlorite schists, slate (hard, black, flinty, to soft, green, talc), shale, sandstone, trap and basalt."

The series containing the syenite, gneiss, quartzite, protogene, crystalline and chlorite-schists is here placed by the writer in the supposed Cretaceous. Its approximate area is not known, neither is its thickness where the central core of the western extension of the Olympics is exposed. Along the east and west axisof the western part of the peninsula at Beaver Falls, on the East Clallam-La Push wagon-road, which is composed of a very hard, dark-gray plutonic rock of more than 10,000 feet in thickness. This core, however, is exposed only in patches. Its greatest thickness is in the vicinity of Clallam Peak. Towards Cape Flattery it is capped with sedimentary deposits. Here it is composed of metamorphosed sandstone and quartzite. It may prove to be of Eocene age.

At Portage Head, Point of the Arches, and at Point Granville the type rock of this old series is conglomerate, quartzite, old diabase or greenstone, serpentine, etc.

This old series, wherever found, is much fractured and faulted and cut by quartz veins, which occasionally carry gold and silver in small quantities. The principal veins carrying precious metals are found in the Point of the Arches group and in the vicinity of Clallam Peak and Beaver Falls. An odor of benzine is also given off from the serpentine and conglomerate rocks of this group in the Point of the Arches, derived likely from the shales that are found a mile further south. There are no other shales or oil-producing rocks in the vicinity; the age of these shales is in doubt, but they are Cretaceous or still younger.

As a closing remark on this formation, the observations seem to show that the oldest rocks of the peninsula are those on the Pacific coast mentioned above, together with those in the Clallam Peak group (?). The Pacific coast groups were islands in a Cretaceous sea, and around them were deposited the next formation described. The western extension of the Olympic axis, including the Clallam Peak group, was caused by an upthrust movement along this line at or near the close of Miocene times. Where the mainland mass was in pre-Cretaceous times cannot be even suggested at this time.

Supposed Cretaceous.—There are three groups of rocks which are here placed in the supposed Cretaceous list: The soft to hard green slate (talc) of the upper Bogachiel country; the hard gray sandstone and flinty slates of the north slopes of the Olympics; and the pre-Oligocene rocks on the Pacific coast not given in the previous supposed pre-Cretaceous list. The correlation is based on the stratigraphic position and the lithologic character of the rocks.

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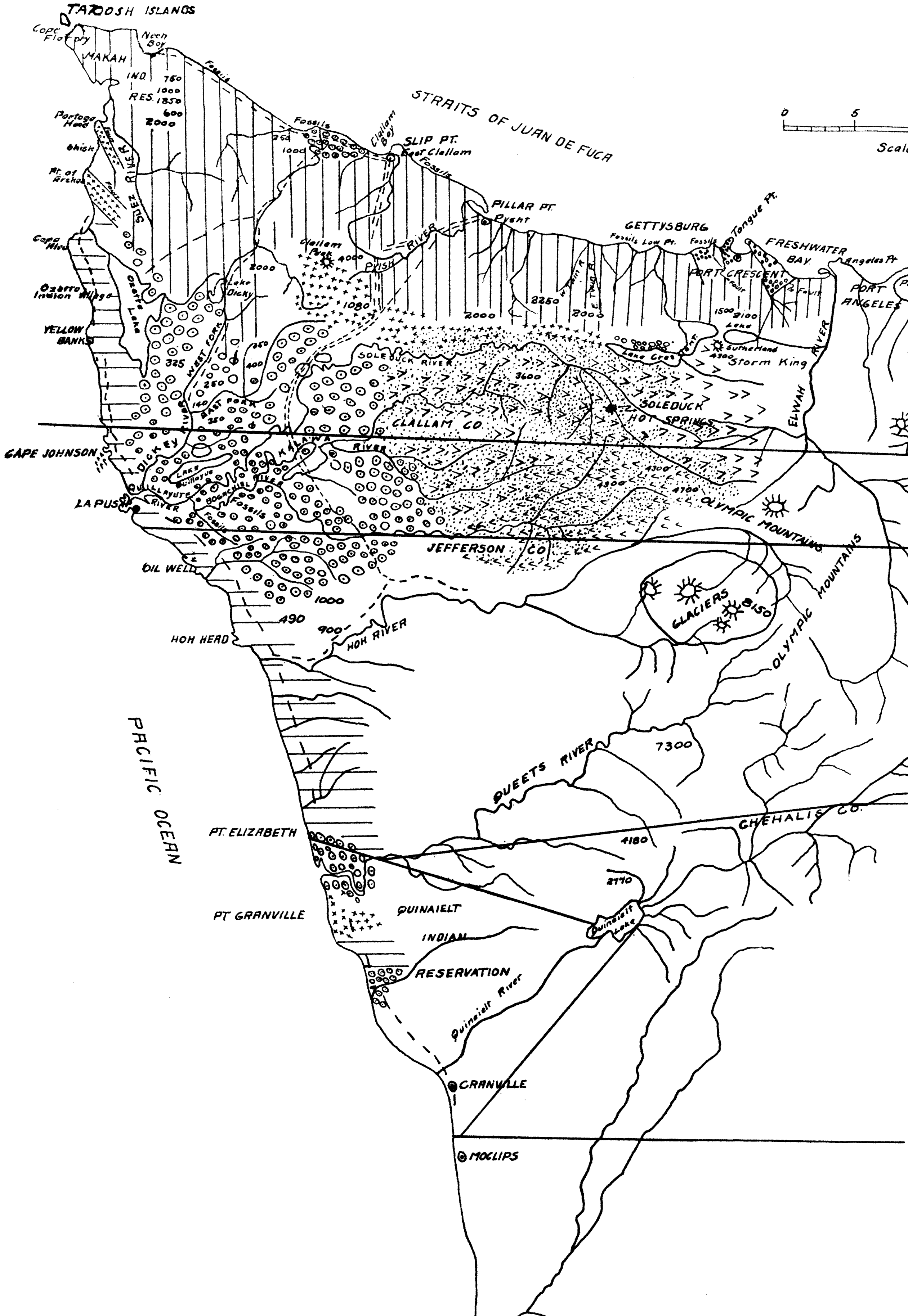
[20] National Geographic Magazine, vol. 7, 1896, p. 138.

The green talc series is found in the Bogachiel valley near the head waters of that stream. It is several thousand feet in thickness. For the most part it is a soft slate interbedded with gray sandstone and some shale. It is pitched nearly to a vertical position, with a trend of dip between a southeast and a northwest and an east and west direction in the region visited. The next formation described above is superimposed upon it. It extends to the Hoh valley and likely to the region of the glaciers, judging from the milky-colored sediment in the glacial waters of the Hoh river. It is also found unconformably beneath the supposed Cretaceous sandstone series of Johnson Point on the coast north of the mouth of the Quillayute river. It is in this formation that the Bogachiel and Hoh rivers have cut their respective cañon-like channels. No fossils were found in this formation. On account of its reaching its greatest development in the Bogachiel valley, it is here termed the Bogachiel formation.

The second group of supposed Cretaceous rocks extends from the Eocene exposures near Port Crescent south to about four miles south of the Soleduck Hot Springs. At the north it is mostly hard gray sandstone; but nearing the Soleduck, and between the tributaries of that stream, it is for the most part a flinty, dark-colored slate, though soft carbonaceous shales are found exposed on the south slope of the ridge which separates the main channel of the Soleduck from its northern fork. On weathering the flinty slate takes on an iron-rust color. In this region it was found that the nucleus of all the ridges was this flinty slate; the streams have cut their channels in the softer sandstones and shales. From the Soleduck Springs south to the top of the Soleduck-Bogachiel divide the formation is alternating—very hard to soft shale and sandstone. The rocks are raised nearly to vertical position, the trend being nearly east and west. South of the river about 20,000 feet of continuous rock are exposed on the surface; and, the rock standing practically on end, its thickness would be about the same number of feet. North of the Soleduck the thickness of the rock must be as great or greater, but its approximate thickness could not be determined, as the country is much broken by faults. And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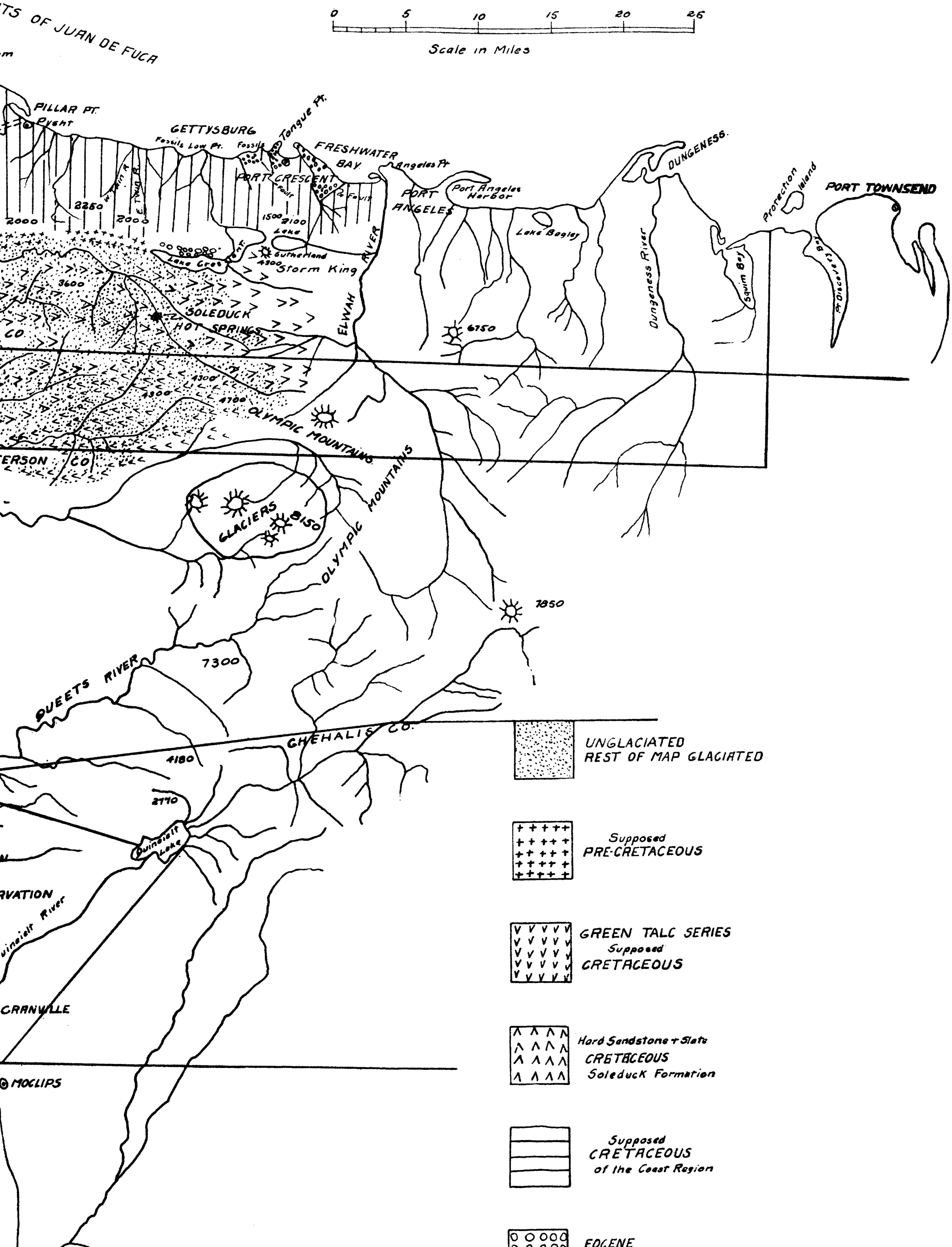

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REST OF MAP GLACIATED
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GREEN TALC SERIES
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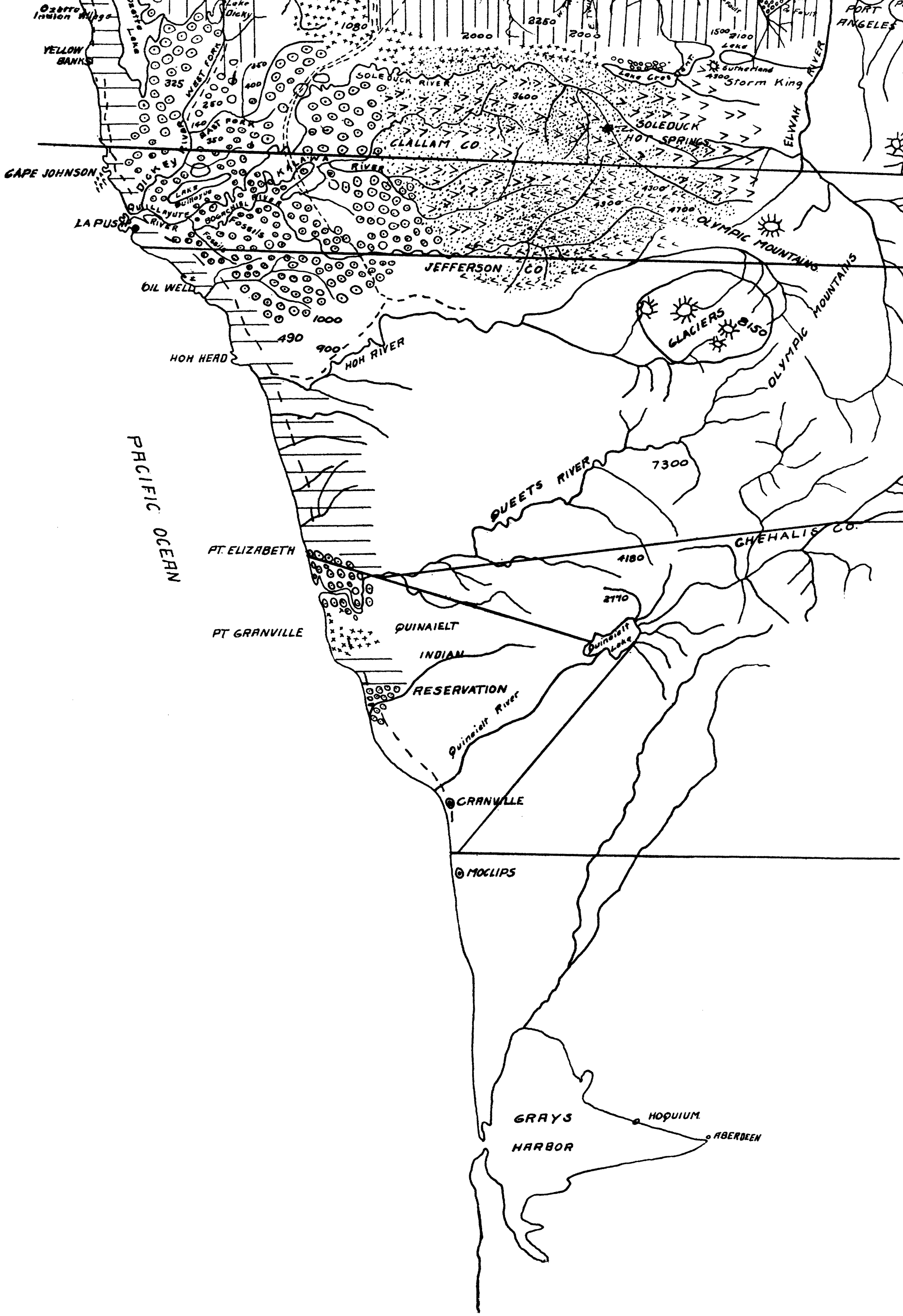
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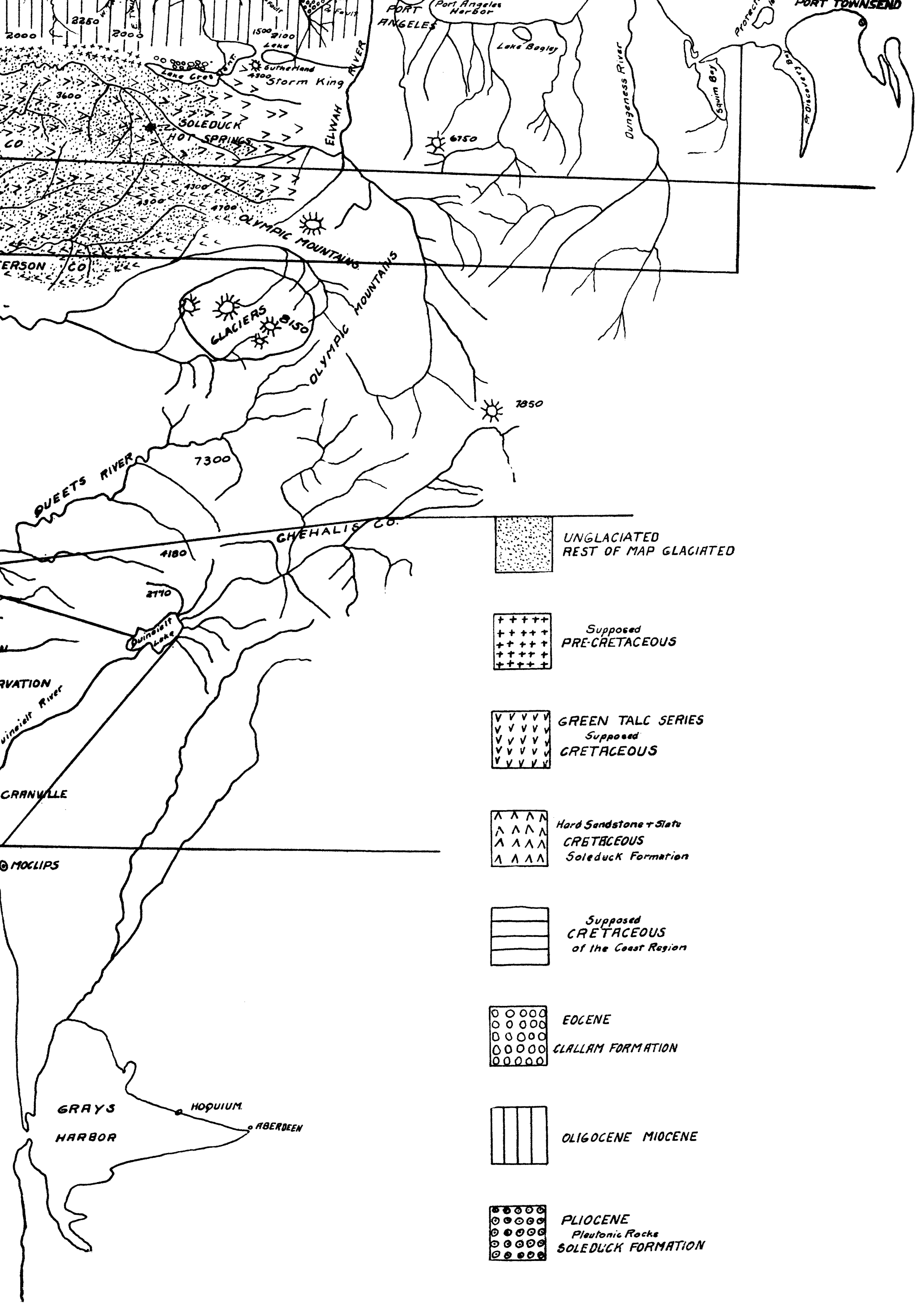
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CRETACEOUS
of the Coast Region
EOCENE
CLALLAM FORMATION
OLIGOCENE MIOCENE
PLIOCENE
Plutonic Rocks
SOLEDUCK FORMATION

the faulting still continues; the present ridges contain great cracks and fissures, often miles in length, and show every sign of even recent earthquake disturbances.

Below is a partial section of the rock of the ridge which separates the Soleduck from its north branch (the North Fork) 600 yards above the bridge on the government trail, beginning on its down-stream side:

Gray sandstone	100	feet.
Very flinty, dark slate, weathering to an iron-rust brown,	120	"
Gray sandstone	40	"
Dark slate, often having the luster of hard coal	300	"
Gray sandstone	20	"

This formation is seen to dip under the Eocene of the Port Crescent region(?). In two summers the writer was unable to find a fossil in it. For convenience this formation will hereafter be called the Soleduck formation.

The third group of supposed Cretaceous rocks is exposed on the Pacific coast and extends as a narrow strip from about two miles south of the Point of the Arches to near Cape Elizabeth on its northern side. It consists of coarse gray, often very massive sandstone, with occasional zones of dark shale, which is coal-bearing in a few places, though the veins are always thin. A conglomerate rock is also found interbedded in the formation now and then. This formation also extends to the islands off the coast. The axis of the uplift has a general southeast-northwest trend, corresponding roughly to the coast-line and the trend of the dip of the strata, which dip in a general way to the northeast, varying locally to a northwest dip in many places. The angle of the dip varies from thirty degrees to sixty degrees, averaging about forty-five degrees in the vicinity of La Push. The formation extends inland, from a mile in the vicinity of Ozette lake to about two miles at Johnson Point, while south of the Quillayute river it widens eastward.

From the farthest island off the coast to the most northerly limit inland of this formation, on a line at right angles to the trend of the dip of the strata, the distance is about six miles. The average dip being forty-five degrees, this would give more than 15,000 feet as the thickness of the rock thus exposed, 10,000 feet of which is in the submerged platform.[21]

The series is characterized by its having calcite veins running through it in all directions. These are abundant in nearly all exposures, but are most pronounced in the rocks of the islands off the coast, especially in those exposed in the Jagged island group.

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[21] One of the islands off the coast is characteristic for having its strata dip southwest, directly opposite to the dip of the strata of its sister islands; this seems to be due to some local faulting.

Indications of oil are very noticeable in the soft gray sandstone of this series about a mile south of the Point of the Arches, and also at several locations on the coast south of the Quillayute river. Oil-springs also occur on Hoh head a mile north of the mouth of the Hoh river. Oil is also said to have been found at several places down the coast south of the Hoh.

This formation may be a continuation of the sandstone series of the Olympic region; but lack of time has prevented the writer from making a detailed examination of the middle Soleduck-Bogachiel country. The formation seems, however, to continue as a ridge to the mountains, as the divide between the Hoh and the eastern tributaries of the Quillayute.

This formation is not a continuous wall along the coast farther west than the mouth of 'the Quillayute river. From that point northwestward it has been broken through by streams and the sea at different times till now it represents "island" patches surrounded on three sides by unlithified material and on the front by the sea. They were islands in the Pliocene and Pleistocene times, as will be stated later; now they are often mere headlands, peninsulas or semi-islands, where the later deposits have not been entirely removed from them so that they again stand out from the coast as islands. They are the last remnants of this supposed Cretaceous ridge. To consider them as a whole, they may be termed "monadnocks."

Eocene: Crescent Formation.—This formation has a very limited exposed area. It comprises only the region in the vicinity of Crescent Bay and the prominent ridge which extends along the coast from this bay east to Freshwater Bay and some of the ridges that lie west of the south half of Lake Crescent (?). It is composed of volcanic material throughout. Its lowest exposure is on Tongue Point, on the west side of Crescent Bay, though the base of the formation is not there exposed. There it is black massive basalt some 200 feet in thickness. Superimposed upon the basalt are about 200 feet of greenish basalt tuffs and tufaceous sands. And superimposed upon this series are again 200 feet of black vesicular basalt; the whole likely representing several surface flows. A Freshwater Bay section also gives 600 feet of basalt and massive basalt tuff at base of exposure. On this are exposed 400 feet of thin-bedded green tuff, over which are superimposed 200 feet of black vesicular basalt. Another small exposure is also found on the coast about a mile west of Tongue Point.

The age of this series of rocks is easily determinable. The roughly bedded tuffs in their upper portion are fossiliferous. In them Doctor Arnold found' *Venericardia planicosta* Lamark, *Turritella uvasana* Conrad, and other characteristic fossils which indicate the Eocene age of the series and its general contemporaneity with the Tejon of California.[22]

This volcanic formation is very extensive, but is mostly covered up with later deposits; the conglomerate series of the next formation above it, even to Cape Flattery, is made up in part of fragments of basalt and basalt tuff, and is the only volcanic rock exposed *in situ* in the region. The portion exposed is separated from the later rocks by an erosive period and by faults.

Oligocene-Miocene: Clallam[23] *Formation.*—This formation is extensive and is found superimposed upon the Eocene and older rocks from Freshwater Bay to Cape Flattery along the Strait of Fuca, extending to the Pacific in the Cape Flattery promontory.[24] It is composed of conglomerates, sandstones, and shales, the latter two being rich in fossils. The conglomerates are found mostly at the base and near the top of the series along the strait and in the middle of the Cape Flattery series. A generalized section of this formation, from Freshwater Bay to Waatch Strait, by Doctor Arnold, gives the following:[25]

Coal-bearing coarse sandstones and conglomerates..	500 feet.
Massive gray shales and fine gray sandstones.......	1,300 "
Fine gray shale, massive at top, thin-bedded below,	975 "
Coarse conglomerates, with occasional sandstone layers and lenses..............................	875 "
Total..	3,650 feet+.

And the Waatch-Neah Bay section gives 15,000 feet of conformable strata, all of which seem to belong to this age of rocks.

Along the coast the shales occur principally in the middle of the series. In the vicinity of Crescent lake they seem to be wanting altogether; the walls of the lake where examined at the eastern terminus of the lake were composed of a dark-colored coarse to gravelly sandstone, approaching the conglomerate stage. From Gettysburg westward in from the coast a few miles to the top of the divide the country rock is generally shale; along the East of Clallam-La Push wagon-road it is the country rock from a mile south of East Clallam the whole distance to the summit of the divide. This shale at its base is thinly bedded and plainly laminated, but higher up in the series becomes almost massive clay, while in the disturbed central region it becomes a hard slate or "slag-like" rock.

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[22] Bull. Geol. Soc. Am., vol. 17, p. 460.

[23] Following Doctor Arnold, it is deemed best to use the above term, as the separation of the two members of the group will necessarily have to be made on paleontological grounds, and the writer does not feel that material enough has been collected to make that possible at the present time.

[24] Since this paper was written a fossil, *Thyasira bisecta* Con., has been found in the shale on the Pacific front three miles south of La Push and one and a half miles south of the old oil-well prospect. This would seem to place even the coast series (supposed Cretaceous) in the Miocene, at least all the rocks above the conglomerate series exposed on the coast.

[25] Coal in Clallam county, Wash., U. S. Geol. Surv., Bull. No. 260, p. 415.

The whole region from near Port Crescent to Gettysburg exposes shale. This contains nodules, boulders and concretions of flint; sometimes the flint forms a partial stratum. The shale is dark brown on exposed surfaces; otherwise irony gray. An overthrust is shown in these beds about a mile west of Gettysburg; and near that place hydrogen sulfid gas was noticed to be escaping from cracks in the shale. Sandstone dikes also cut the shale now and then in the region between Twins and Pysht; these are likely derived from the interbedded sandstone.

Where the Hoko river cuts its cañon through the Olympic axis, it exposes hard slate, shale and sandstone. The block of slate east of the river here dips generally to the northeast. On the ridge the dip is only about ten degrees; but as the straits are neared it becomes steeper and steeper, reaching even seventy degrees in some places. From the main ridge here several cross-ridges extend southward, apparently of the same formation.

From the Sekiu river a mile and a half in from the straits there runs a ridge northward to Neah Bay, with northeasterly dipping strata. The rock in the center of this ridge is a dark, very hard, "slag-like rock," between a flint and a slate.

The basal conglomerate is usually very hard and is composed of pebbles and cobbles of granite, gneiss, quartzite, jasper, agate, black to green slate, and volcanic rock, mostly basalt and basalt tuffs. In the upper conglomerate series the volcanics are mostly wanting.

The sandstones, for the most part, are thin-bedded, hard, and resistant to erosion. At East Clallam they are immediately below the upper conglomerates, and in the Cape Flattery promontory they are found at the base and near the top of the formation. They are quite fossiliferous, especially at Gettysburg and East Clallam. In them, especially at Slip Point, fragments of coal are found and thin, taperingout layers of impure coal of the lignitic type are occasionally met with; while towards Pillar Point from East Clallam are the Clallam coal-beds of this formation, a mention of which will be made later. The scattered fragments of coal in the sandstone seem to have been formed from driftwood; each fragment of coal so formed seems to have been a fragment of a log or stump isolated from all other coal-producing material.

About a half-mile up the Sekiu river, and at several places along the coast from the mouth of that river to Neah Bay, a massive sandstone was observed which contains concretions of fine, very hard, bluish-gray sandstone containing fossils; some of the concretions also contain pyrites of iron. The concretions resemble Doctor Newcomb's "boulders" of the Carmanah Point formation on Vancouver Island adjacent;[26] and as the fossils are similar it is likely that the formations are the same. In the sandstone series here, especially in that exposed along the Sekiu, there are occasionally small veins of coal, a sort of "decayed vegetation." The veins exposed are too small and the coal is too poor in quality to ever pay to handle.

The cap-rock from the Sekiu to Neah Bay is very coarse, dark-colored sandstone to a very massive gravelly rock, approaching the conglomerate stage. Underneath it is a gray to yellowish finer-grained sandstone, superimposed upon the shale series previously mentioned.

West of Waatch Strait to Cape Flattery, on the strait side, the formation is thin-bedded to massive, hard, iron-gray to rusty-brown slate and sandstone, and on the Pacific side it is mostly dark gray slates and thin-bedded sandsone, while in the central area and apparently forming the core of the promontory are coarse sandstones and gravelly and coarse conglomerates. The latter seem to be almost wholly made up of volcanic material. Whether the cementing material was volcanic also could not be determined. The bulk of the mass was mostly angular blocks, all of volcanic origin. There were volcanic bombs and basalt fragments that were easily recognized. The basalt fragments showed beyond doubt that they had been cooled on a land surface. Almost all had vesicular spaces, some of which are now filled with calcium carbonate. As the volcanic material of this region seems to have all been ejected in Eocene times, it is quite possible that the shales and sandstones to the westward of this conglomerate series will prove to be Eocene in age.

Note.—The finding of a fossil, *Thyasira bisecta* Con., on the Pacific front, as has been previously noted in a foot-note, shows that this formation rims the Quillayute synclinal trough.

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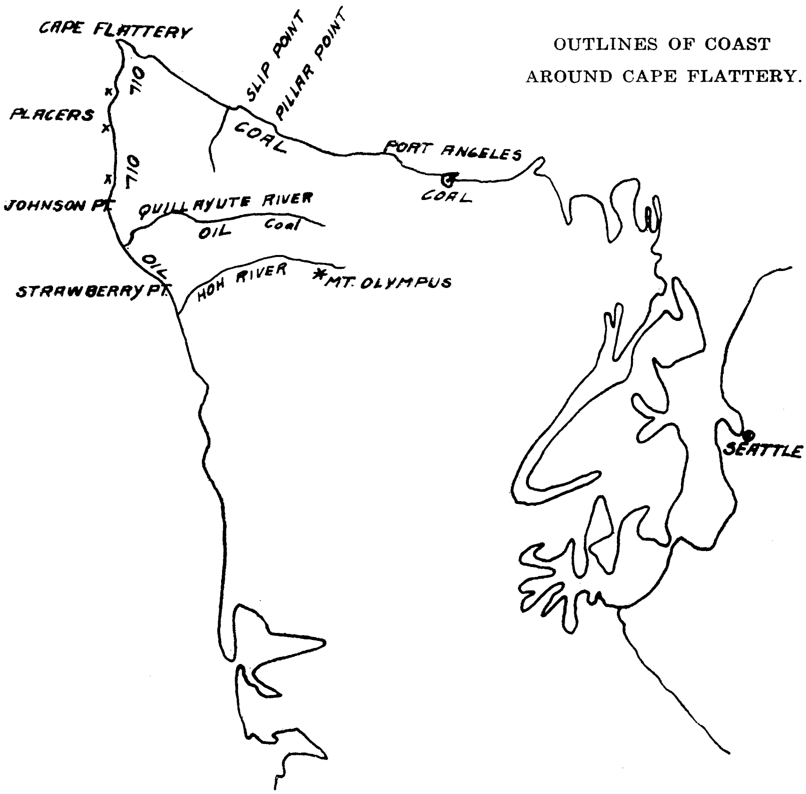
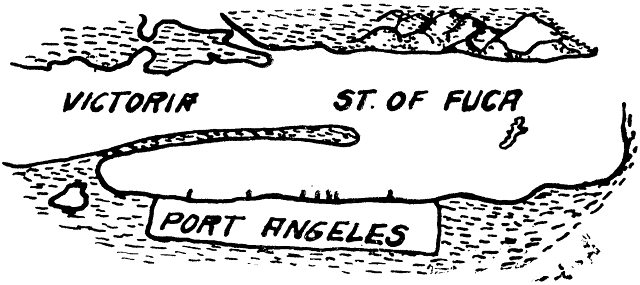
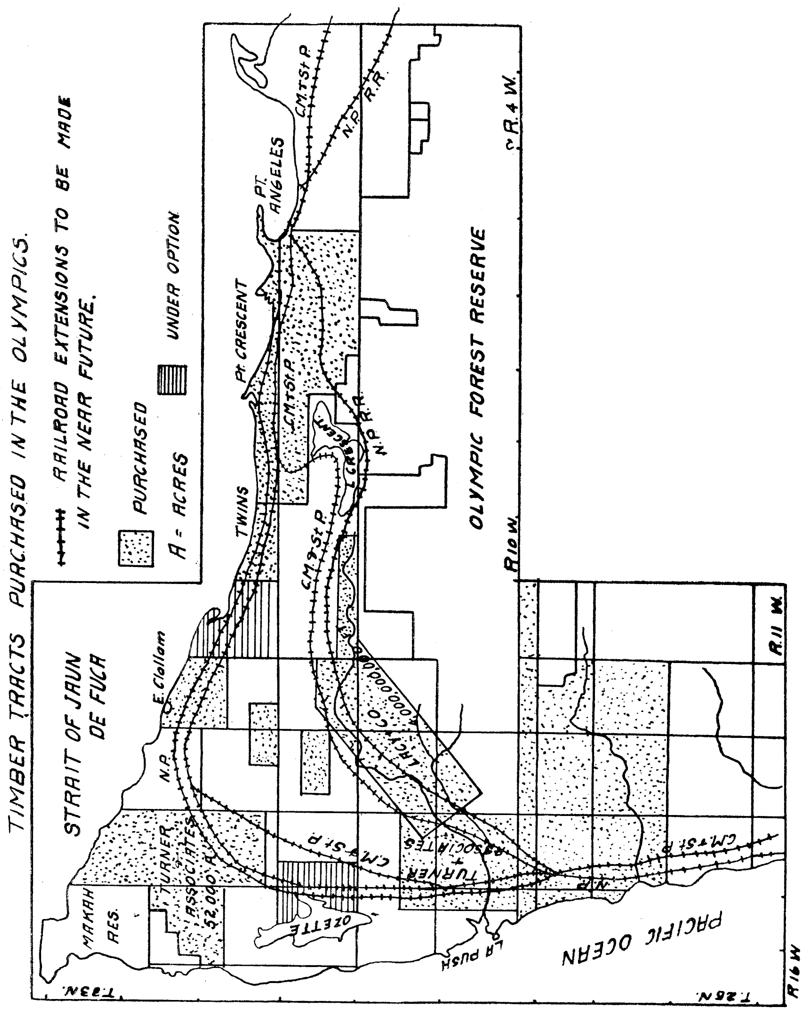
[26] Merriam, Univ. Cal., Bull. Dept. Geol., vol. 2, No. 3, p. 102.

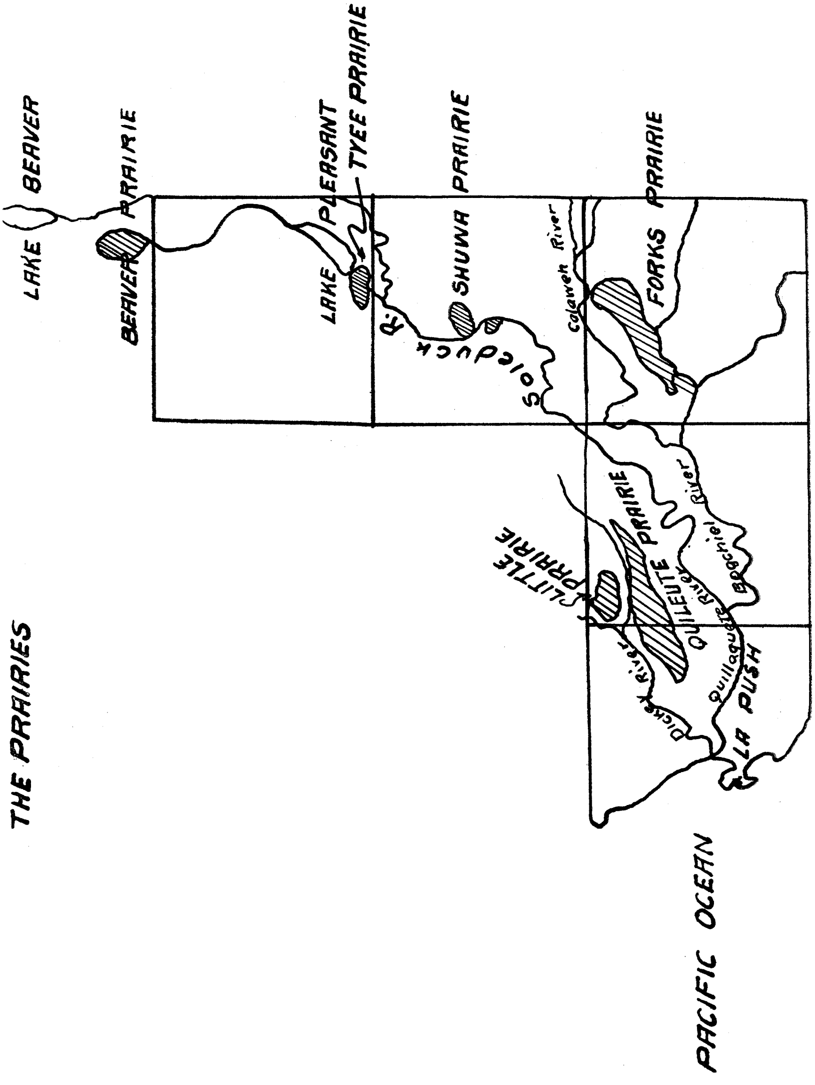


OUTLINES OF COAST AROUND CAPE FLATTERY.

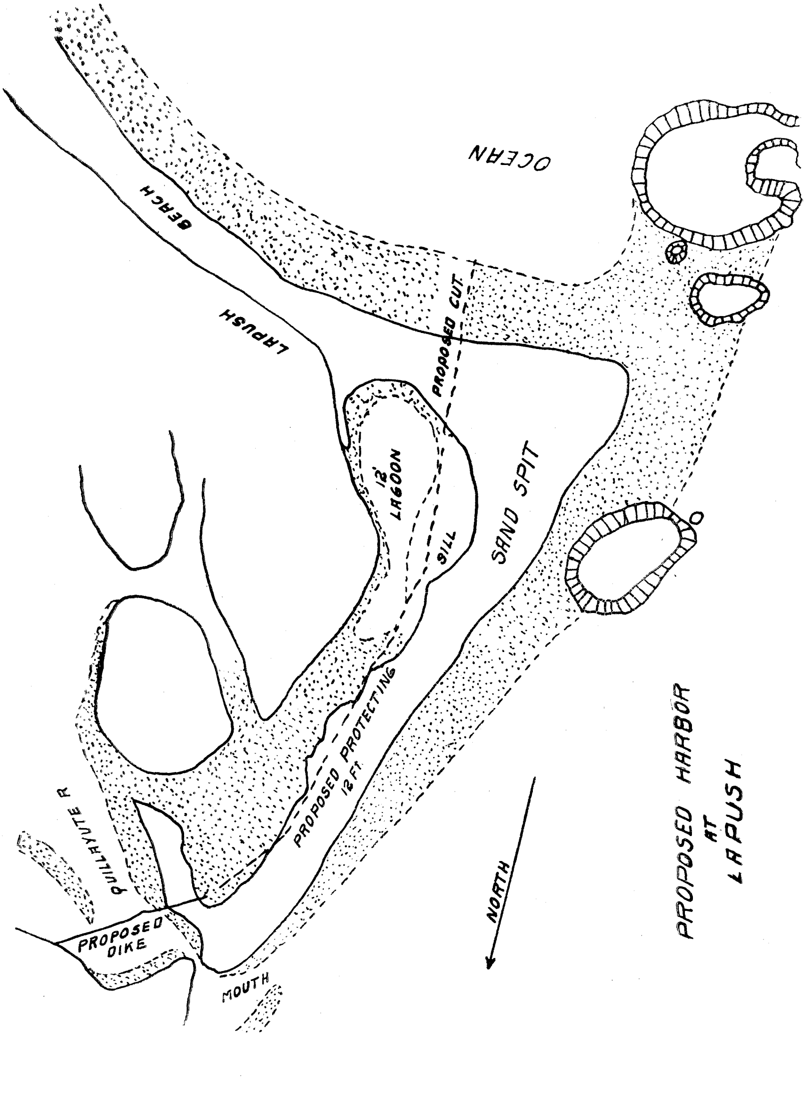


HARBOR OF PORT ANGELES.


TIMBER TRACTS PURCHASED IN THE OLYMPICS.
RAILROAD EXTENSIONS TO BE MADE IN THE NEAR FUTURE.
PURCHASED
UNDER OPTION
A = ACRES
STRAIT OF JAUN DE FUCA
E. Clallam
N.P.
TWINS
Pt. CRESCENT
PT. ANGELES
C.M.&St.P.
N.P. R.R.
R.4 W.
OLYMPIC FOREST RESERVE
R10W.
L. CRESCENT
LACY CO. 100,000 A.
TURNER + ASSOCIATES
TURNER & ASSOCIATES 52,000 A.
MAKAH RES.
OZETTE
LA PUSH
PACIFIC OCEAN
R.11 W.
R16 W.
T.33N.
T.26N.



THE PRAIRIES


OCEAN
LAPUSH BEACH
PROPOSED CUT
12' LAGOON
SILL
SAND SPIT
PROPOSED PROTECTING 12 FT.
QUILLAYUTE R
PROPOSED DIKE
MOUTH
NORTH
PROPOSED HARBOR AT LAPUSH

FOSSILS FROM THE OLIGOCENE-MIOCENE OF WASHINGTON ON THE STRAIT OF JUAN DE FUCA.

So far as the writer can learn, these are the first fossils ever described from this region; and the only fossils so far described that resemble them are the Astoria (Oregon) fossils of Conrad,[27] and possibly those of the Sooke District, and of Carmanah Point of Vancouver Island.[28]

The arrangement of the species and the respective numbers of the families given are after Arnold.[29]

In this treatise, as in that of the Pliocene shells later, the measurements of the respective shells are given in millimeters, unless otherwise stated, and the number of the shell given in the plate is the number of the description of the same. All the shell drawings are natural size, unless otherwise stated. The illustrations are from drawings by my wife, Mrs. Otilla A. Reagan.

The locality from which each shell was obtained is stated in the description of that shell.

In submitting the shell descriptions, the writer wishes to thank Doctor Branner of Stanford University for the free use of the books of his large geological library; and especially the volumes of the Pacific Railroad Report and those of the Wilkes's Exploring Expedition; also Gabb's two volumes on the Palaeontology of California[30] and Mr. Ralph Arnold's Monograph on the Paleontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California.[31]

FOSSILS FROM THE CLALLAM FORMATION.

List of fossils obtained from the lower clay shales exposed near Gettysburg, Wash.:

Obtained by the writer.	*Obtained by Doctor Arnold.*[32]
Solemya ventricosa Conrad.	Solemya rubroradiata Conrad.
	Leda sp.
	Nucula sp.
Yoldia impressa Conrad.	
	Pecten clallamensis Arnold.
	Pecten waylandi Arnold.
Thracia trapezoides Conrad.	

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[27] Am. Jour. Sci., vol. 55, 1848, pp. 432, 433, figs. 1-14; and Wilkes's Exploring Expedition, vol. X, pp. 722-730, pls. 17-20.

[28] Univ. Cal. Geol., vol. 2, No. 3, pp. 101-108.

[29] Mem. Cal. Acad. Sci., vol. III, 1903.

[30] Pal. Cal., vol. I, 1864; vol. II, 1869.

[31] Loc. cit.

[32] Geol. Soc. Am., vol. 17, pp. 451-468, pls. 55-58, 1904.

Obtained by the writer.	*Obtained by Doctor Arnold.*
Phacoides acutilineatus Conrad.	Phacoides acutilineatus Conrad.
Venus (Chione) vespertina Conrad.	
Venus (Chione) angustifrons Conrad.	
Tellina albaria Conrad.	Tellina sp.
Mactra gibbsana Meek.	
Dentalium substriatum Conrad.	Dentalium substriatum Conrad.
	Fusus sp.
	Marginella or Erato sp.
	Natica sp.
Polynices (Neverita) reclusiana Petit.	
Polynices (Neverita) saxea Conrad.	
Polynices (Lunatia?) olympidii n. s.	
Cyrodes aff. dowelli White.	
	Perissolax sp.
Dolium petrosum Conrad.	
Dolium biliratum Conrad.	
Chrysodomus gettysburgensis n. s.	
Purpura canaliculata Ducal.	
	Aturia cf. ziczac Sowerby.
? Macrocystis cf. pyrifera?.	

List of fossils from the sandstone (upper) horizon of Gettysburg:

Obtained by the writer.	*Obtained by Doctor Arnold.*
Solemya ventricosa Conrad.	Solemya rubroradiata Conrad.
	Leda sp.
Nucula (Acila) castrensis Hinds.	
Nucula (Acila) gettysburgensis n. s.	Nucula sp.
Phacoides acutilineatus Conrad.	Phacoides acutilineatus Conrad.
	Cytherea cf. vespertina Conrad.
Venus (Chione) mathewsonii Gabb.	
Venus (Chione) temblorensis Anderson.	
Pellina albaria Conrad.	Tellina (Angulus) sp.
	Thracia cf. trapezoides Conrad.
Mactra gibbsana Meek.	
Dentalium substriatum Conrad.	
	Cylichna petrosa Conrad.
	Dolium petrosum Conrad.
	Fusus sp.
	Natica sp.
Polynices (Neverita) reclusiana Petit.	
Polynices (Neverita) saxea Conrad.	
Polynices (Lunatia?) olympidii n. s.	
Trochita inornata Gabb.	
Olivella pedroana Conrad.	
	Perissolax (?) sp.
	Pleurotoma sp.
	Scala sp.
? Macrocystis cf. pyrifera ?.	

List of fossils from the lower horizon, exposed at East Clallam:

Obtained by the writer.	*Obtained by Doctor Arnold.*
Nucula (Acila) castrensis Hinds.	
Yoldia impressa Conrad.	
	Arca sp.
Phacoides acutilineatus Conrad.	
Venus (Chione) angustifrons Conrad.	Venus (Chione) aff. temblorensis Anderson.
Venus (Chione) olympidea n. s.	
Venus (Chione) clallamensis n. s.	
	Cytherea cf. vespertina Conrad.
Saxidomus gibbosus Gabb.	
	Pecten fucanus Dall.
	Pecten propatulus Conrad.
Tellina arctata Conrad.	Tellina arctata Conrad.
Tellina arctata, var. Juana, n. var.	
Tellina clallamensis, n. s.	
Mactra gibbsana Meek.	
Teredo sp.	
Teredo bulbosus n. s.	
Dentalium substriatum Conrad.	
	Fusus oregonensis Conrad.
	Natica sp.
Polynices (Neverita) saxea Conrad.	
Polynices (Lunatia?) olympidii n. s.	
	Sigaretus scopulosus Conrad.
Trochita inornata Gabb.	
Pisania clallamensis n. s.	
?Macrocystis cf. pyrifera?.	

List of fossils from the middle horizon exposed at East Clallam:

The fossils are found in a dark-colored slate (shale) and slaty sandstone to a very hard, dark-colored, massive sandstone, containing fragments of coal and charred wood; the color of the rock is due to its bituminous constituents:

Obtained by the writer.

Yoldia impressa Conrad.
Pectunculus patulus?.
Pecten (Chlamys) fucanus Dall?.
Pecten (Chlamys) wattsi, var. Morani Arnold?.
Pecten (Pantinopecten) propatulus Conrad?.
Venus (Chione) clallamensis n. s.
Tellina arctata Conrad.
Tellina clallamensis n. s.
Metis alta Conrad.
Mactra gibbsana Meek.
Dentalium substriatum Conrad.
Polynices (Neverita) saxea Conrad.
Sigaretus scopulosus Conrad.
?Macrocystis cf. pyrifera?.

List of fossils from near the top of the Clallam formation as exposed at East Clallam, Wash., in the vicinity of the lighthouse:

Obtained by the writer.	*Obtained by Doctor Arnold.*
	Chione aff. temblorensis Anderson.
Venus (Chione) clallamensis n. s.	
Tellina arctata Conrad.	Tellina sp.
Mactra gibbsana Meek.	Mactra sp.
	Mytilus aff. mathewsonii Gabb.
Panopea generosa Gould.	Panopea generosa Gould.
	Pecten fucanus Dall.
	Phacoides acutilineatus Conrad.
	Crepidula prærupta Conrad.
Dentalium substriatum Conrad.	Dentalium substriatum Conrad.
	Fusus sp.
	Scala (Opalia) sp.
Polynices (Neverita) saxea Conrad.	
Pisania clallamensis n. s.	
?Macrocystis cf. pyrifera?.	

List of fossils from the upper beds of the Cape Flattery section. Mr. Arnold's species are from the mouth of the Sekiu river; the fossils obtained by the writer are from a point on the coast five miles east of Neah Bay, Washington:

Obtained by the writer.	*Obtained by Doctor Arnold.*
	Cardium aff. quadrigenarium Conrad.
	Leda sp.
	Mactra sp.
	Nucula sp.
Nucula (Acila) gettysburgensis n. s.	
Yoldia impressa Conrad.	
	Yoldia sp.
Phacoides acutilineatus Conrad.	
Phacoides cf. nuttallii Conrad.	
Thyasira bisecta Conrad.	
	Tellina aff. bodegensis Hinds.
	Cancellaria sp.
	Cylichna sp.
	Dentalium sp.
	Fusus sp.
	Natica sp.

DESCRIPTION OF FOSSILS OBTAINED BY THE WRITER.

MOLLUSCA.

Class PELECYPODA; Order PRIONODESMACEA.
Family I SOLEMYACIDÆ; Genus *Solemya* Lam.

Shell Soleniform, equivalve, low-beaked, edentulous, gaping.

1. *Solemya ventricosa* Conrad. Plate I, fig. 1.

Solemya ventricosa Con. Wilkes's Expl. Exped., vol. X, p. 723, pl. 17, figs. 7-8.

Conrad's description:[33] "Oblong, ventricose; dorsal and ventral margins straight and parallel; anterior side narrowed, the margin orbiculate; posterior margin scalloped; the interior half truncated obliquely inward; 'beaks distant from the anterior extremity; lateral surface smooth, radiated with narrow bands."

This is a very common species in both the upper and lower series of the Oligocene-Miocene rocks at Gettysburg, Wash., but is most abundant in the upper series.

Miocene at Astoria Ore. (Conrad); Oligocene-Miocene, Gettysburg, Wash. (Reagan).

Superfamily NUCULACEA; Family VI NULULIDÆ; Genus *Nucula* Lamarck.

"Shell trigonal, with the umbones turned towards the short posterior side; smooth or sculptured; epidermis olive; interior pearly; margins crenulated; hinge with prominent internal cartilage-pit, and a series of sharp teeth on each side; pallial line simple. Type, *Arca nucleus* Lam." (Arnold.)

Subgenus *Acila* H. & A. Adams.

Shell with divaricate structure.

2. *Nucula* (*Acila*) *castrensis* Hinds. Plate I, fig. 2.

Nucula castrensis Hinds, Proc. Zool. Soc., 1843, p. 98; also, Hinds Voy. Sulphur, p. 61, pl. 17, fig. 5.

Nucula (*Acila*) *castrensis* H. & A. Adams, Genera. Rec. Moll., vol. 2, p. 545.

Nucula divaricata Con., Wilkes's Expl. Exped., vol. X, p. 725, pl. 18, fig. 6; also, Am. Jour. Sci. 1848, p. 432, fig. 1.

Nucula decisa Con., P. R. R. Rept., vol. V, p. 222, pl. 3, fig. 19.

Nucula conradi Meek, Smithsonian Check List (*fide* Gabb, Pal. Cal., vol. 11, 1869, p. 102).

Acila castrensis Hinds, Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 227; Williamson, Proc. U. S. Nat. Mus., vol. XV, 1892, p. 192. Dall, Trans. Wagner Inst. Sci., vol. III, 1898, p. 572.

Acila lyalli Baird (*fide* Carpenter, Brit. Assn. Rept., 1863, p. 644).

Nucla (*Acila*) *castrensis* Hinds, Arnold, Mem. Cal. Acad. Sci., vol. III, pp. 95, 96.

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[33] Loc. Cit.

Shell small, subovate to trigonal and subrhomboidal, convex, of medium thickness; beaks posterior to center, turned posteriorly; posterior end short, obliquely truncated; anterior end long, rounded; surface marked by divaricating striæ; hinge with numerous sharp teeth on each side and with prominent internal cartilage-pit.

This is a very variable species; its range covers the entire Tertiary series represented in this region, though it is rare in the Oligocene-Miocene formation along the Strait of Fuca. It is very abundant in the Quillayute Pliocene. Specimen figured is from the Quillayute formation.[34]

Living: Sitka to San Diego (Cooper); Puget Sound; Quillayute Bay (Reagan).

Pleistocene: San Pedro (Arnold); San Diego to Santa Barbara (Cooper; Gabb).

Pliocene: San Fernando (Gabb; Cooper); San Diego well (Cooper); San Pedro, Cal. (Arnold); Quillayute, Wash. (Reagan).

Miocene: Astoria, Ore. (Conrad; Cooper; Gabb); Martinez; Griswold's, San Benito county, California (Cooper).

Oligocene-Miocene: Blakely, near Seattle, Wash. (Arnold); Gettysburg, East Clallam, Wash. (Reagan).

3. *Nucula* (*Acila*) *gettysburgensis* n. s. Plate I, fig. 3.

Shell resembling *N.* (*Acila*) *castrensis* Hds. but much larger. Shell trigonal, convex, medium thickness; umbones considerably posterior to center, turned posteriorly, posterior end 16, anterior extremity 24.5 from umbones; posterior end short, truncated, concave back of umbones; anterior end rounded to arcuate, forming an acute angle with the anterior extremity; ventral and cardinal margins subparallel; lunule area large, slightly scooped out, sculptured same as rest of shell; a low ridge fronts each valve back of the lunule area, back of which there is a wide, flat, curved sinus extending from the umbo to the ventral margin, widening as it approaches that margin; surface divaricately sculptured, also ornamented with about seven concentric low ridges; inside of shell not seen.

Dimensions: Lat., 28; alt., 19.5.

The shell figured is from the Gettysburg formation.

This shell is easily distinguishable from *N. castrensis* Hds. by its larger size, more truncated, concave posterior extremity, large lunule, and by its umbones being placed more posteriorly; and

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[34] The specimens obtained from East Clallam possess a finer surface sculpture than those of the Quillayute formation.

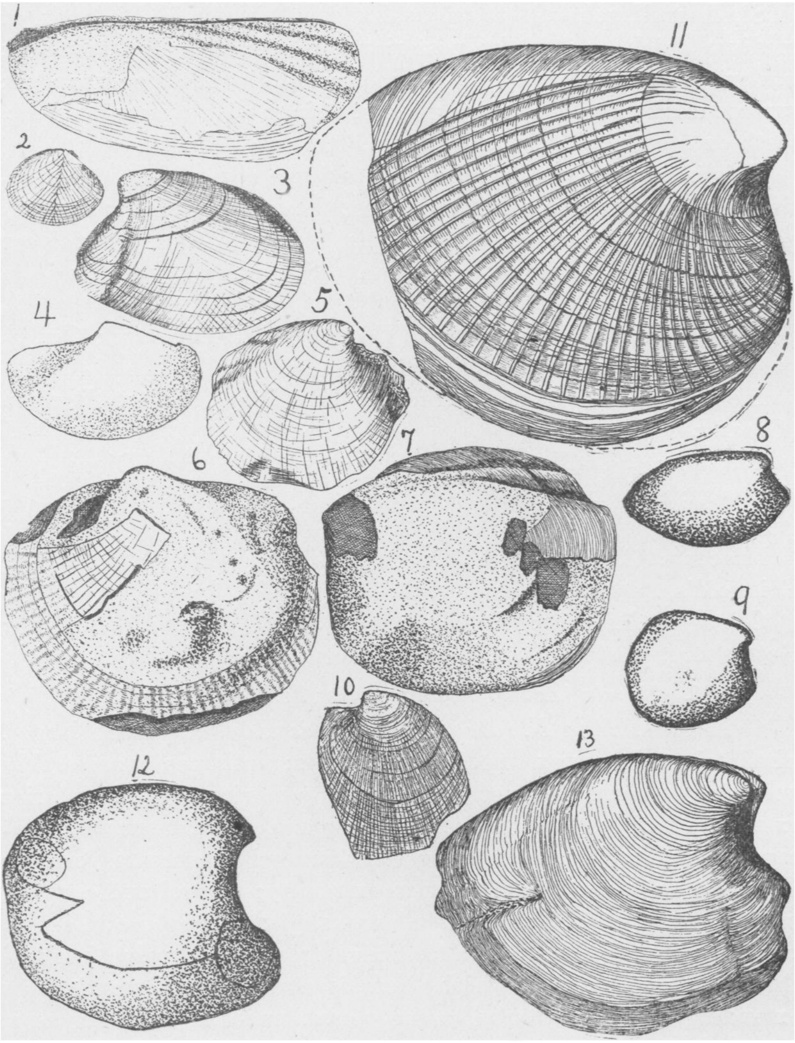

PLATE I.

Fig. 1. Solemya ventricosa Conrad.
Fig. 2. Nucula (Acila) castrensis H. & A. Adams; left valve.
Fig. 3. Nucula (Acila) gettysburgensis n. s.; left valve.
Fig. 4. Yoldia impressa Conrad; cast of right valve.
Fig. 5. Phacoides acutilineatus Conrad; a cast; times, one-half.
Fig. 6. Phacoides cf. nuttallii Conrad; a cast.
Fig. 7. Thyasira bisecta Conrad.
Fig. 8. Venus (Chione) vespertina Conrad; a cast; times, one-half.
Fig. 9. Venus (Chione) angustifrons Conrad; a cast; times, one-half.
Fig. 10. Venus (Chione) mathewsonii Gabb; a much broken specimen; times, one-half.
Fig. 11. Venus (Chione) temblorensis Anderson.
Fig. 12. Venus (Chione) olympidea n. s.; a cast.
Fig. 13. Venus (Chione) clallamensis n. s.; a cast.

from *N. truncata* Gabb by its size, its larger and more pronounced umbones, by the large concave area posterior to umbones, and by the low ridge on the posterior dorsal front of each valve, back of which extends the posteriorly curved sinus from umbo to ventral margin, and which continues to widen as it approaches the latter. It resembles some of the Japanese species, both living and Tertiary, very much, but has the beaks pitched and curved more backward.

Only two specimens were obtained from the upper series of the Clallam formation at Gettysburg, and one from the Neah Bay section of the same formation.

Genus *Yoldia* Möller.

"Shell oblong, slightly attenuated behind, compressed, gaping, smooth or obliquely sculptured, with a dark-olive shining epidermis; external ligament slight; cartilage as in *Leda;* pallial sinus deep. *Yoldia myalis* Couth. is a characteristic species." (Arnold.)

4. *Yoldia impressa* Conrad. Plate I, fig. 4.

Nucula impressa Con., Wilkes's Explo. Exped., vol. X, p. 726, pl. 18, fig. 7.
Yoldia impressa Meek, Sm. Check List, Miocene.
Yoldia cooperi Gabb (in part), Proc. Cal. Acad. Sci., 1865, p. 189.
Yoldia cooperii Cpr., Cooper (in part), Enumerations of West Coast Mollusca.

Conrad's description:[35] "Oblong ovate, convex, with regular concentric impressed lines. Anterior extremity rostrate, slightly recurved, extremity truncated; ligament-margin arcuate, slightly declining; rounded behind. Beaks submedial. Basil margin arcuate, slightly contracted near the anterior extremity."

The fine lines of the surface are neat, but closely crowded. The apical angle is about 160 degrees.

This species is very variable. The length varies from one to two and one-half inches; the breadth of the mature shells is usually about one-half inch.

The shells of this species are much more gibbous than the shells of *Yoldia cooperi,* and are also much shorter.

This species was found in the Gettysburg shales of the Oligocene-Miocene series; also in the lower and middle series of the same formation at East Clallam. The shells in the Gettysburg series were found to be larger than those obtained at East Clallam.

The shell figured is from the Gettysburg formation.

Miocene: Astoria, Ore. (Conrad); between Martinez and Monte Diablo, Cal.; Astoria, Ore. (Cooper; Gabb).

Oligocene-Miocene: Gettysburg, East Clallam, Wash. (Reagan).

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[35] Loc. cit.

Superfamily ARCACEA; Family VII ARCIDÆ.
Subfamily PECTUNCULINÆ; Genus *Pectunculus* Lam.

Pectunculus patulus?.

A much-worn specimen, apparently of this species, was obtained from the middle series of the Clallam formation as represented at East Clallam.

Superfamily PECTINACEA; Family IX PECTINIDÆ; Genus *Pecten* s. s.

4½ *a.* *Pecten* (*Chlamys*) *fucanus* Dall?.
4½ *b.* *Pecten* (*Chlamys*) *wattsi* var. *morani* Arnold?.
4½ *c.* *Pecten* (*Pantinopecten*) *propatulus* Con.?.

Only fragments of *Pectens*, doubtfully classed as above, were obtained at East Clallam, in the middle series there; no *Pectens* were found at any other horizon.

Order ANOMALODESMACEA; Superfamily ANATINACEA.
Family XIV THRACIIDAE; Genus *Thracia* (Leach) Blainville.

4½ *d.* *Thracia trapezoides* Conrad.

Thracia trapezoides Con., Wilkes's Expl. Exped., p. 723, pl. 17, fig. 6.

Conrad's description:[36] "Trapezoidal; ventricose; flank flattened, carinate; side anteriorly compressed; surface faintly concentric undulate and neatly but unequally marked with concentric striæ; beaks prominent, medial; posterior margin truncated; basal margin tumid at middle; casts have surface faintly concentric undulate; muscular impressions rather indistinct, the posterior quite small; pallial sinus large."

Only a fragment of a shell of this species was obtained in the Oligocene-Miocene shales near Gettysburg, Wash.

Miocene: Tomales, Cal. (Gabb).

Post-Pliocene: Astoria (Conrad); Eagle Prairie (Gabb).

Oligocene-Miocene: Gettysburg, Wash. (Arnold; Reagan).

Superfamily LUCINACEA; Family XXI LUCINIDÆ.
Genus (*Phacoides*) *Lucina* Brugiere.

Shell rounded, orbicular, convex, white; umbones depressed; lunule usually present and distinct; margins crenulated or smooth; ligament oblique, semi-internal; dentition usually normal, two hinge teeth in each valve, two lateral teeth in right valve, four in left; rugose muscular impressions; posterior extremity oblong; anterior elongated within the pallial line; umbonal area with a deep furrow. Characteristic species, *Lucina jamaicensis* Linne.

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[36] Loc. cit.

5. *Phacoides acutilineatus* Conrad. Plate I, fig. 5; times, one-half.

Lucina acutilineata Con., Wilkes's Expl. Exped., vol. X, p. 725, pl. XVII, fig. 2, 1849.

Cyclas acutilineata Con., Jour. Conch., 1865, p. 153.

Lucina borealis (not of Linne's Syst. Nat. Edition XII, p. 1413); of Carpenter, Brit. Assn. Rept., 1863, p. 643.

Pectunculus patulus Con., Jour. Conch., 1865, p. 153 (not Wilkes's Expl. Exped., p. 726, pl. XVIII, fig. 9).

Lucina tertica Con. (*fide* Gabb, Pal. Cal., vol. II, p. 100, 1869).

Lucina borealis of Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 246.

Lucina acutilineata Con., Arnold, Mem. Cal. Acad. Sci., vol. III, pp. 131–132.

Phacoides acutilineatus Con., Arnold, Geol. Soc. Amer., vol. 17, pp. 463–464 (mentioned in list only).

Arnold's description:[37] "Shell large, orbicular, only slightly convex, rather thin; umbones depressed, central; surface ornamented by numerous equal, equidistant, sharp, raised, concentric lines; interspaces show lines of growth; lunule small, but deeply impressed and distinct; two sharp cardinal teeth in each valve; lateral teeth nearly obsolete; anterior muscle-impression much elongated."

Dimensions of largest specimen obtained: Lat., 70; alt., 60; diam., 26.

This species is very common in the Oligocene-Miocene strata of the region along the Strait of Juan de Fuca; the specimen here figured was obtained at East Clallam.

Living: Catalina Island (Cooper); Santa Barbara channel (Carpenter); Puget Sound (Arnold).

Pleistocene: Santa Barbara to San Diego, Cal. (Cooper); San Pedro, Santa Barbara, San Diego (Arnold).

Pliocene: Stanford University (Arnold); San Fernando, San Diego well, Santa Barbara, Santa Cruz, Santa Rosa, Sargent's, Santa Clara county, California (Cooper).

Miocene: Astoria and various other places in Oregon; Martinez, Orestima Cañon, Stanislaus county; Foxin's, Santa Barbara county; Griswold's, San Benito county, California (Cooper); Point Blakely, near Seattle, Wash. (Arnold).

Oligocene-Miocene: Gettysburg, East Clallam, Wash. (Arnold; Reagan); Neah Bay, Wash. (Reagan).

5½. *Phacoides nuttallii ?* Conrad.

A fragment of a shell containing the peculiar markings of this species was found in the Quillayute formation at the mouth of Maxfield creek.

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[37] Loc. cit.

6. *Phacoides cf. nuttallii* Conrad. Plate I, fig. 6.

Only a cast was obtained. Shell small, orbicular, slightly convex; umbones depressed, small, central; surface marked by numerous concentric lines and radiating ridges.

Specimen obtained from the Oligocene-Miocene formation near Neah Bay, Wash. This is the cast figured in the plate.[38]

Family XXIII CRYPTODONTIDÆ; Genus *Thyasira.*

"Shell globular, posterior side furrowed or angulated; umbones much recurved; lunule short or indistinct; ligament usually and to a certain extent external, placed in a groove on the hinge line, and outside the hinge-plate; teeth altogether wanting." (Arnold.)

7. *Thyasira bisecta* Conrad. Plate I, fig. 7.

Venus bisecta Con., Wilkes's Expl. Exped., vol. X, p. 724, pl. XVII, figs. 10–10*a*, 1849.

Thyasira bisecta Con., Meek, Smithsonian Check List, Miocene Fossils, 1864.

Cyprina bisecta Con., Jour. Conch., 1865, p. 153.

Conchocele bisecta Con., Gabb, Pal. Cal., vol. II, p. 99, 1869.

Conchocele disjuncta Gabb, Pal. Cal., vol. II, pp. 28–29, pl. VII, fig. 48, 1869. Cooper, 7th An. Rept. Cal. St. Min., 1888, p. 236.

Cryptodon bisectus Con., Dall, Proc. U. S. Nat. Mus., vol. XV, 1892, p. 189; vol. XVII, 1894, p. 713, pl. XXVI, figs. 2–5.[39]

Thyasira bisecta Con., Arnold, Mem. Cal. Acad. Sci., vol. III, pp. 135–136, pl. XV, fig. 5.

Shell large, subquadrate, subrhomboidal, ventricose, convex, of medium thickness; anterior end very short, abruptly truncate, angulate below, with submarginal ventral furrow and the inferior margin at its termination slightly excavate; cardinal margin arched, sloping downwards towards the posterior end; surface strongly excavate from upper side of the beak to the posterior margin and subcarinate below the excavation; beaks terminal, anterior pointed forward; ligament long, elliptical, forming a regular curve with the supero-posterior margin; large lunular area in front of beaks; basal margin generally arcuate.

A single specimen was obtained in an exposure on the beach-front near Neah Bay on the Strait of Juan de Fuca.

Living: Puget Sound, sixty-nine fathoms (Dall).

Pliocene: San Pedro, Cal. (Arnold).

Miocene: Astoria, Ore. (Conrad); Blakely, near Seattle, Wash. (Arnold).

Oligocene-Miocene: Neah Bay, Wash.; on the Pacific coast, three and one-half miles south of the mouth of the Quillayute river, Clallam county, Washington (Reagan).

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[38] A shell resembling *Phacoides annulatus* Reeve also occurs in this formation.

[39] After Arnold, loc. cit.

Superfamily VENERACEA; Family XXVII VENERIDÆ.
Subfamily VENERINÆ; Genus *Venus* Linne.

"Shell thick, ovate, smooth, sulcated, or cancellated; margins minutely, crenulated; cardinal teeth, three in each valve; pallial sinus small, angular; ligament prominent; lunule distinct."

Subgenus *Chione* Megerle.

"Shell oval, triangular or subcordiform; margins finely crenulated; hinge narrow, solid, with three teeth in the right valve and two in the left, the interior tooth longest; ligament narrow; pallial sinus shallow. *Venus gnidia* Brod. is a characteristic species."[40]

8. *Venus* (*Chione*) *vespertina*, Conrad. Plate I, fig. 8; times, one-half.
Cytherea vespertina Con., Am. Jour. Sci., 1848, p. 432, fig. 9.
Dione vespertina Con., Jour. Conch., 1865, p. 152.

Conrad's description:[41] "Acutely ovate, ventricose, very inequilateral; summits prominent; surface with concentric lines which are not very smooth and regular; posterior side somewhat cuneiform; anterior extremity acutely rounded; basal margin rounded."

The cast of a single specimen was obtained from the lower shales near Gettysburg.

Miocene: Oregon (Conrad).

Oligocene-Miocene: Gettysburg, Wash. (Reagan).

9. *Venus* (*Chione*) *angustifrons* Conrad. Plate I, fig. 9; times one-half.
Venus angustifrons Con., Wilkes's Expl. Exped., vol. X, p. 724, pl. 17, fig. II.
Dione angustifrons Con., Jour. Conch., 1865, p. 152.

Conrad's description:[42] "Subtrigonal, ventricose; ligament margin very oblique and slightly curved; long posterior margin direct, truncate; basal margin arcuate; latter surface everywhere convex, and having thin, concentric, elevated lamellæ."

Specimen figured is a cast from the lower shales at Gettysburg, Wash., the only specimen obtained, except one which was found in the lower series at East Clallam.

Miocene: Astoria, Ore. (Conrad).

Oligocene-Miocene: Snohomish, Wash. (Arnold); East Clallam, Gettysburg (Reagan).

10. Venus (*Chione*) *mathewsonii* Gabb.

Chione mathewsonii Gabb., Pal. Cal., vol. *II*, p. 23, 1869. Plate I, fig. 10; times, one-half.

Shell large, very thick, subcordiform to subtriangular and obliquely cordate; beaks small, pointed forward and placed well anteriorly; cardinal margin sloping rapidly but slightly convex; base broadly rounded; surface sculptured by numerous frills and numerous fine, crowded, radiating lines; interior of valve not seen.

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[40] Arnold, loc. cit., pp. 146, 147.

[41] Am. Jour. Sci. above.

[42] Wilkes's exped. above.

Classification made by comparing specimens with specimens in the museum of the Leland Stanford Junior University.

The shells obtained differ from *C. mathewsonii* Gabb in that Gabb's shell lacks the sculpture.

Dimensions of largest specimen obtained: Length, 78; alt., 60.

The specimens were obtained from the lower Pliocene at Quillayute, Wash., in which formation they seem to be rare. A much-broken specimen was also found in the upper series of the Oligocene-Miocene formation at Gettysburg.

Specimen figured is from the Quillayute formation.

Miocene (?) of California (Gabb).

Upper Pliocene: Capitola, Cal. (Arnold).

Lower Pliocene: Quillayute, Wash. (Reagan).

Oligocene-Miocene: Gettysburg, Wash. (Reagan).

11. *Venus (Chione) temblorensis* Anderson. Plate I, fig. 11.

Venus (Chione) temblorensis Anderson, Cal. Acad. Sci., 3d ser., Geol., vol. II, No. 2, p. 196.

Anderson's description:[43] "Shell subtriangular in outline; beaks slightly incurved; lower margin rounded; hinge margin rather straight; surface ornamented with concentric ridges and radiating ribs, the ridges rising in gently fluted and ruffled folds."

Dimensions: Lat., 55; alt., 52.

The specimen figured was obtained from the upper series of the Clallam formation at Gettysburg, Wash., the only specimen of this species obtained.

Lower Miocene: Beds of Kern river and Temblor, California (Anderson).

Upper Oligocene-Miocene: Gettysburg, Wash. (Reagan).

12. *Venus (Chione?) olympidea* n. s. Plate I, fig. 12.

Description from a cast: Specimen medium-sized, suboval, convex to gibbous; surface ornamented with fine to coarse concentric lines of growth (judging from a few small fragments of the shell); beaks large, high, anterior, terminal, pointed forward; lunule area large; hinge robust; posterior muscular impression deep, circular; pallial sinus deep, small, triangular; pallial line deep, continuous.

Dimensions: Lat., 37; alt:, 37.5; diam., 27.5; from beak to posterior extremity, 37; to anterior extremity, 21.

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[43] Loc. cit.

This species differs from the other *Venus* species obtained in its short, robust, gibbous shape.

The specimen described is from the lower series at East Clallam; it is the only specimen of the species found.

13. *Venus* (*Chione*) *clallamensis* n. s. Plate I, fig. 13.

Shell ovate to subtriangular in outline; beaks considerably anterior to center, incurved; lower margin rounded to subarcuate in old specimens; posterior margin produced to an angle; hinge margin straight; surface ornamented with radiating ribs and concentric ridges (shown on a fragment of the shell); ribs flat, some very fine, others much thickened, formed by the coalescing of two or more smaller ones; ribs coalesce towards the beak, or to proceed from beak toward the base they may be said to be dichotomous; concentric ridges not flattened or ruffled; the concentric ridges show impressions on the casts.

Dimensions of largest specimen obtained: Length (2 inches) 52; alt. (1.8 in.) 48; from apex of umbones to posterior extremity, 52; to anterior extremity, 25; from posterior to anterior extremity, following the base-line, 58. Of a medium-sized specimen: L. (1.75 in.) 45; alt. (1.56 in.) 40; thickness (0.89 in.) 22; from apex of umbo to posterior extremity, 43; to anterior extremity, 22. Of a third specimen: L. (1.5 in.) 38; alt. (1.25 in.) 35; from apex of umbones to posterior extremity, 35.5; to anterior extremity, 22.

Measurements of Mr. Anderson's type specimen of *V.* (*Chione*) *temblorensis* were as follows: "2½ inches in larger diameter, and thickness 2½ inches."[44]

Distinguishable from *V.* (*Chione*) *temblorensis* Anderson by more anterior beaks, dichotomous ribs, the coalescing of some of the ribs and the variableness in the size of the same, and in the shells being less gibbous.

Shell found in all three horizons at East Clallam.

Subfamily TAPETINÆ; Genus *Saxidomus* Conrad.

Shell transversely oval, inequilateral, solid, ventricose; without lunule; umbones tumid; teeth three or four, inequal, narrow, central one bifid; ligament very thick, elongated; muscular impressions oval or rounded, nearly equal; pallial sinus large, elongated. *Saxidomus nuttallii* Con. is the type. (After Arnold.)

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[44] Anderson, Cal. Acad. Sci., Geol. 3d ser., vol. II, No. 2, p. 196.

14. *Saxidomus gibbosus* Gabb. Plate II, fig. 14.

Saxidomus gibbosus Gabb, Pal. Cal., vol. II, p. 58, pl. 16, fig. 18*a–b*, 1869.

Description from cast: Shell subquadrate, very inequilateral; beaks anterior, nearly terminal; anterior end excavated above, narrowly rounded below; posterior end convexedly subtruncated, sometimes, too, a little obliquely truncated; base broadly rounded; cardinal margin gently sloping and slightly convex; a few fragments of the shell show faint lines of growth; inside of shell not seen.

The specimen figured was the only one obtained. It is from the lower shales at East Clallam.

Pliocene: Eagle Prairie, Humboldt county, California (Gabb).

Oligocene-Miocene: East Clallam, Wash. (Reagan).

Superfamily TELLINACEA; Family XXX TELLINIDÆ.

Genus *Tellina* Linne.

Shell more or less elongated; rostrum more or less twisted; two lateral teeth in each valve.

15. *Tellina albaria* (Conrad). Plate II, fig. 15.

Tellina albaria Con., Wilkes's Expl. Exped., vol. X, p. 725, pl. 18, fig. 5.

Shell small, more or less compressed, thin, subtriangular; beaks submedial; anterior extremity obtusely rounded to angulate; posterior end regularly rounded; ventral margin straight at middle; surface practically smooth in young specimens but marked with concentric lines of growth in the older specimens, somewhat strongly in the very old; the shells become more gibbous with age.

Dimensions of a young specimen: Lat., 24; alt., 16; diam., 5. Dimensions of an adult specimen—the specimen figured: Lat., 31; alt., 22; diam., 13.

This species is very common in the Gettysburg shales, also in the sandstone of the upper series at Gettysburg.

Miocene: Astoria, Ore. (Conrad).

Oligocene-Miocene: Gettysburg, Wash. (Reagan).

16. *Tellina arctata* Conrad. Plate II, fig. 16*a*, 16*b*.

Tellina arctata Con., Wilkes's Expl. Exped., vol. X, p. 725, pl. 18, fig. 3; equals *Macoma arctata* Con., Gabb, Pal. Cal., vol. II, 1869.

Shell subelliptical, oblong, compressed; anterior extremity truncate and slightly sinuous, reflected below; basal margin elliptical to arcuate; ligamental margin declining; posterior margin rounded; surface marked by very faint, closely and regularly arranged concentric lines, most of which are obsolete on the worn specimens at hand; beaks small, pointed, and placed nearest the anterior extremity; interior of valve not seen.

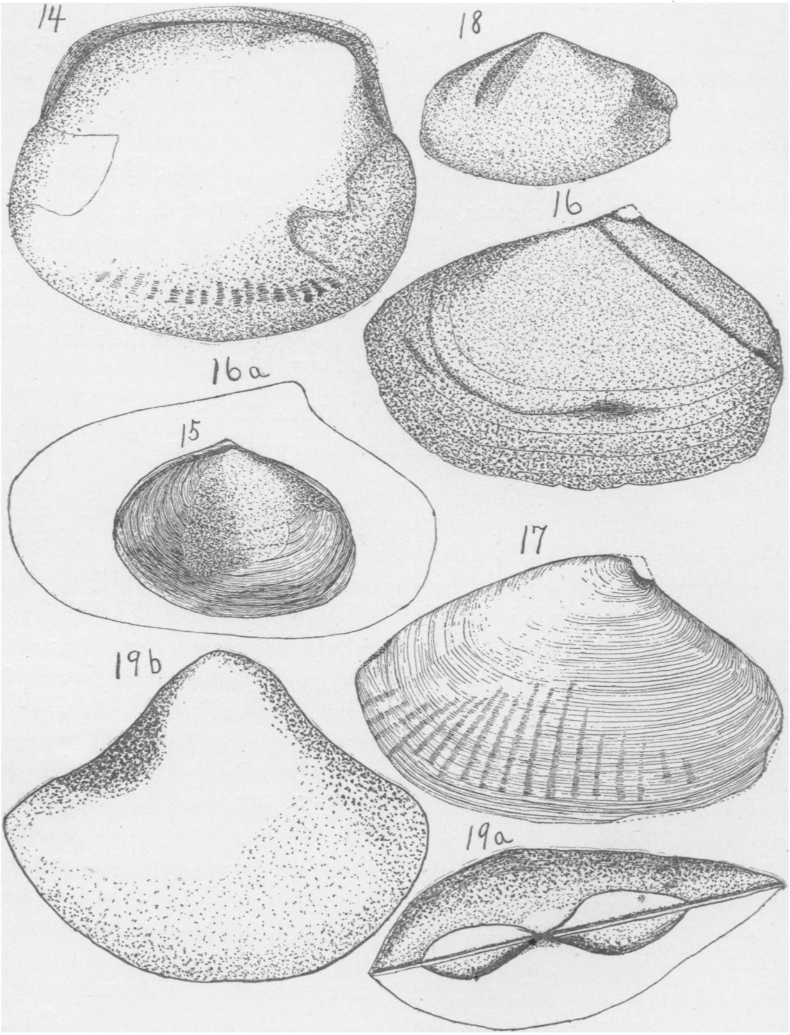

PLATE II.

Fig. 14. Saxidomus gibbosus Gabb ; a cast.
Fig. 15. Tellina albaria Conrad.
Fig. 16. Tellina arctata Conrad ; a cast.
Fig. 16*a*. Outline of another specimen of the same species.
Fig. 17. Tellina arctata ; var. juana n. var.
Fig. 18. Tellina clallamensis n. s. ; a cast.
Fig. 19*a*. Mactra gibbsana Meek ; hinge view of cast.
Fig. 19*b*. Same specimen as 19*a* ; side view.

Dimensions of an average specimen: Length, 50; alt., 35; diam., 16.

The specimens obtained are very variable. So far they have been found only at East Clallam in this region, and principally in the lower horizon there.

Miocene: Astoria, Ore. (Conrad).

Oligocene-Miocene: East Clallam, Wash. (Arnold; Reagan).

17. *Tellina arctata,* var. *juana* n., var. Plate I, fig. 17.

Shell like *Tellina arctata* Con., except ornamented with transverse bands in addition to the faint, closely and regularly arranged concentric lines shown on that species.

Only a single specimen of this variety was obtained from the lower series of the Oligocene-Miocene at East Clallam.

18. *Tellina clallamensis* n. s. Plate II, fig. 18.

Shell somewhat resembling *Tellina bodegensis*, but smaller and thinner.

Shell elongated, elliptical to narrow ovate, compressed, thin; umbones anterior to center, pointed posteriorly; anterior portion of shell almost evenly rounded; posterior dorsal margin slightly depressed back of umbo; posterior extremity obliquely truncate, straight from depressed margin back of umbo, front reflected; inferior margin arcuate to almost straight in some specimens; cardinal teeth not seen; pallial sinus long and thickened anteriorly (?) (only a faint impression seen); anterior muscle-impression on right valve large; ridge in front of impression extends nearly to umbo; posterior muscle-impression in same valve is also surrounded by a rather high ridge which extends nearly to the umbonal regions; the same is true of the muscle-impressions in the left valve. A fragment of unworn shell shows the surface to be marked with fine, regular, closely arranged concentric impressed lines.

Dimensions: Lat., 35; alt., 21; from umbo to posterior extremity, 23; to anterior extremity, 20; length of anterior "muscle-ridge," 14.

This shell can be distinguished from *T. bodegensis* by its being smaller and thinner, by its umbones being placed anterior to center, and by the thickened areas (ridges) on the inner-shell side of the muscular impressions being larger, longer and extending farther toward the umbonal region (a shell of a living *T. bodegensis* at hand gives this ridge as only 8.5 and distant from the apex of umbo 14.5 at dorsal end).

This is a very abundant species in the middle series at East Clallam, and is Oligocene-Miocene in age.

Genus *Metis* H. & A. Adams.

Shell slightly inequivalve, suborbicular, compressed; valve sillonated; posterior flexuosity submedian; no lateral teeth. A characteristic species is *Tellina meyeri* Phil.

18½. *Metis alta* Conrad.

Only the impression of the shallower valve with the angular groove was obtained, but enough to determine the species.

Specimen obtained from the middle series at East Clallam.

Superfamily MACTRACEA; Family XXXV MACTRIDÆ.
Subfamily MACTRINÆ; Genus *Mactra* Linne.

Shell nearly equilateral; anterior hinge tooth A-shaped; lateral tooth doubled in right valve; ligament and resilum separated by a shelly partition; cardinals generally coalescent above; laterals generally smooth, occasionally granular.

Type, *Mactra stultorum* Linne.

19. *Mactra gibbsana* Meek. Plate II, figs. 19*a*, 19*b*.

Matra gibbsana Meek, 1861, Proc. Acad. Nat. Sci. Phil., vol. XIII, p. 315; Bull. U. S. Geol. & Geogr. Surv. Terr., vol. II, No. 4, p. 374, pl. 2, figs. 8, 8*a*-*b*, 1876.

Meek's description (see Geol. & Geogr. Terr. above): "Shell transversely oval, or subtrigonal, moderately convex, rather thin; anterior side narrowly rounded; base forming a regular semi-elliptical curve; posterior side slightly truncated at the immediate extremity, abruptly rounded or subangular at its connection with the base below; dorsal outline sloping from beaks in front and behind at an angle of about 120 degrees; beaks central, rather elevated, but small and not projecting much above the hinge margin; surface marked only by moderately distinct lines of growth; posterior muscular impression oval, well defined; pallial line distinct and provided with a rather deep, horizontal sinus which is about one-third longer than wide."

This species is very abundant in all the series of the Clallam formation exposed along the Strait of Fuca, but most abundant in the lower series at East Clallam.

Dimensions: Length, 55; alt., 41; diam., 24.

Cretaceous or Tertiary(?): Float in Strait of Juan de Fuca (Meek).

Oligocene-Miocene: Gettysburg, East Clallam, Wash. (Reagan).

Superfamily MYACEA; Family XXXVIII, SAXICAVIDÆ.
Genus PAOPEA Menard.

Shell large, thick, equivalve, oblong, gaping widely behind and slightly in front; ligament external, on prominent ridges; an obscure, sometimes prominent, tooth in each valve; pallial sinus deep; surface concentrically or feebly sculptured. *Mya glycymeris* Born. is a characteristic species.

20. *Panopea generosa* Gould. Plate III, fig. 20.

Panopea generosa Gld., Proc. Bost. Soc. Nat. Hist., vol. III, 1850, p. 215. Wilkes's Expl. Exped., vol. XII, p. 385, pl. XXXIV, fig. 507, 1852.

Glycymeris generosa Gld., H. & A. Adams, Gen. Rec. Moll., p. 350, 1853. Carpenter, Brit. Assn. Rept., 1863, p. 637. Gabb, Pal. Cal., vol. II, p. 89, 1869. Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 241. Keep, West Coast Shells, p. 209, fig. 178, 1892. Williamson, Proc. U. S. Nat. Mus., vol. XV, 1892, p. 183. Dall, Wagner Inst. Sci., vol. III, part 4, 1898, p. 830.[45]

Panopea generosa Gld., Arnold, Mem. Cal. Acad. Sci., vol. III, pp. 182, 183.

Shell large and ponderous, rather thin, somewhat quadrilateral in adult specimens; the basal and hinge margins are parallel and straight in adult specimens; posterior extremity broadly truncated, somewhat obliquely; anterior extremity broadly rounded; anteriorly the shell gaps slightly and the valves are somewhat everted; surface coarsely undulating concentrically; beaks sharp and prominent and placed slightly anterior; anterior umbonal slope tumid; posterior slope a little compressed; hinge rather slender, with a single, erect, obliquely triangular tooth in each valve; ligament external; pallial sinus wide and shallow; posterior muscular scar but little broader than the pallial impressions; siphonal sinus shallow, small.

Dimensions of largest specimen obtained: Length, 86; alt., 49; diam., 26.

Living: Puget Sound to San Diego, Cal. (Dall); Neah Bay, Quillayute Bay, Wash. (Reagan).

Pleistocene: San Pedro (Arnold); Santa Barbara to San Diego, Cal. (Cooper).

Pliocene: San Fernando, Santa Barbara (Cooper); Santa Barbara, San Pedro (Arnold); Quillayute, Wash. (Reagan).

Oligocene-Miocene: Upper horizon, East Clallam, Wash. (Reagan).

This species is rare both in the Pliocene and in the Oligocene-Miocene formations.

The specimen figured is from the Upper horizon, East Clallam.

Superfamily ADESMACEA; Family TEREDINIDÆ; Genus *Teredo* Linne.

21. *Teredo* sp. Plate II, fig. 21.

A float-rock found near East Clallam contained many tubes of a small *Teredo*, but the species could not be determined.

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[45] After Arnold, loc. cit.

22. *Teredo bulbosus* n. s. Plate III, fig. 22.

"Cast" of large size, cylindrical, and characterized by having bulbs or nodes on it at frequent intervals.

Specimen obtained from the lower series at East Clallam; formation, Oligocene-Miocene.

Class SCAPHOPODA; Order SOLENOCONCHIA.
Family XL BENTALIIDÆ; Genus *Dentalium* Linne.

Shell tube-like, tapering, with strong longitudinal ribs and with apical notch short or wanting.

23. *Dentalium substriatum* Conrad. Plate III, fig. 23.

Teredo substriata Con., Wilkes's Expl. Exped., 1850, p. 728, pl. 20, fig. 7.
Dentalium substriatum Woodw., Brit. Assn. Rept., 1856.
Dentalium substriatum Con., Jour. Conch., 1865, p. 151.

Shell nearly straight, cylindrical, very slightly tapering.

Fragments of this shell are found throughout the entire fossil-bearing sections of the Clallam formation.

Miocene: Astoria, Ore. (Conrad; Gabb).

Oligocene-Miocene: Gettysburg, East Clallam (Arnold; Reagan).

Class GASTROPODA; Superorder STREPTONEURA.
Order CTENOBRANCHITA; Superfamily TOXOGLOSSA.
Family LIV OLIVIDÆ; Genus *Olivella* Swainson.

Shell small, cylindrical, polished; spire produced, acute; suture canaliculated; aperture narrow behind; somewhat enlarged anteriorly; columella plicated in front, callous posteriorly; canal very short. *Olivella biblicata* Sowerby is a characteristic species.

24. *Olivilla pedroana* Conrad. Plate III, fig. 24.

Strephona pedroana Con., Pac. R. R. Rept., vol. V, p. 327, pl. VI, fig. 51, 1854.

Olivella boetica Carpenter, Brit. Assn. Rept., 1863, p. 661. Gabb, Pal. Cal., vol. II, p. 75, 1869. Tryon, Man. Conch., p. 71, pl. XVII, figs. 28, 31, 34, 1883. Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 225. Keep, West Coast Shells, p. 42, fig. 21, 1892. Williamson, Proc. U. S. Nat. Mus., vol. XV, 1892, pl. XIX, fig 7.[46]

Olivella pedroana Con., Arnold, mem. Cal. Acad. Sci., vol. III, pp. 220, 221, 1903.

Shell small, elongate-elliptical; spire elevated, conical, about equal in height to the aperture; aperture elongate-triangular; columella not seen.

The shell is distinguishable from *O. intorta* by its slender form, smaller size and more elevated spire.

A single specimen of this species was found in the upper series of the Clallam formation at Gettysburg. It is an abundant species in the Pliocene of the Quillayute formation.

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[46] After Arnold, loc. cit.

Living: Strait of Fuca to San Diego, Cal. (Cooper).

Pleistocene: Santa Barbara to San Diego, Cal. (Cooper); San Pedro, Los Cerritos, Spanish Bight and Pacific Beach, San Diego, at Barstow's ranch, Ventura (Arnold).

Pliocene: Kirker's Pass, San Diego well, Twelve Mile House, Seven Mile Beach, Cal. (Cooper); San Pedro, Cal. (Arnold); Quillayute, Wash. (Reagan).

Oligocene-Miocene: Gettysburg, Wash. (Reagan).

Specimen figured is from the Quillayute formation.

Family LVII FASCIOLARIIDÆ; Subfamily, FUSINÆ; Genus *Pisiana* Bivona.

"Shell oblong; spire prominent; whorls smooth or spirally striated; canal very short; outer lip thickened and crenulated. *Pisiana pusio* Linne is a characteristic species." (Arnold.)

25. *Pisiana clallamensis* n. s. Plate III, fig. 25.

Shell of medium size, biturbinate to fusiform; spire broadly conical, elevated; whorls five or six (top of spire broken), angularly ventricose; three low angular ridges revolve on each whorl— one just in front of the suture, its posterior slope joining the suture, and two on the body of the whorl, with a somewhat wide band between them; upper side of volutions obliquely sloping; lower side rounded; surface ornamented with very fine, revolving lines; suture distinct; aperture oval-pyriform; outer lip thick; umbilicus perforate.

Dimensions: Height of body whorl and first whorl of spire, 35; height of body whorl, 30; lat. of body whorl, 23; aperture, 22 x 14.

This species is found in the Oligocene-Miocene in both the upper and lower series at East Clallam. The specimen figured is from the lower series.

Family LVIII BUCCINIDÆ; Genus *Chrysodomus* Swainson.

Shell fusiform, elongate-ovoid, inflated, sometimes sinstral; spire elevated; whorls rounded; apex papillary; aperture oval; canal short, sometimes bent; inner lip simple, smooth.

26. *Crysodomus gettysburgensis* n. s. Plate III, fig. 26.

Shell much broken, large, fusiform; spire elevated; whorls sharply angulated, forming an unkeeled spiral table; surface unornamented; aperture pyriform; inner lip incrusted; canal curved backwards.

Demensions: Lat. of body whorl, 38; of next whorl, 24; alt. of body whorl, exclusive of canal, 39; of next whorl, 13.

This species differs from *C. tabulatus* Baird in its larger size, in

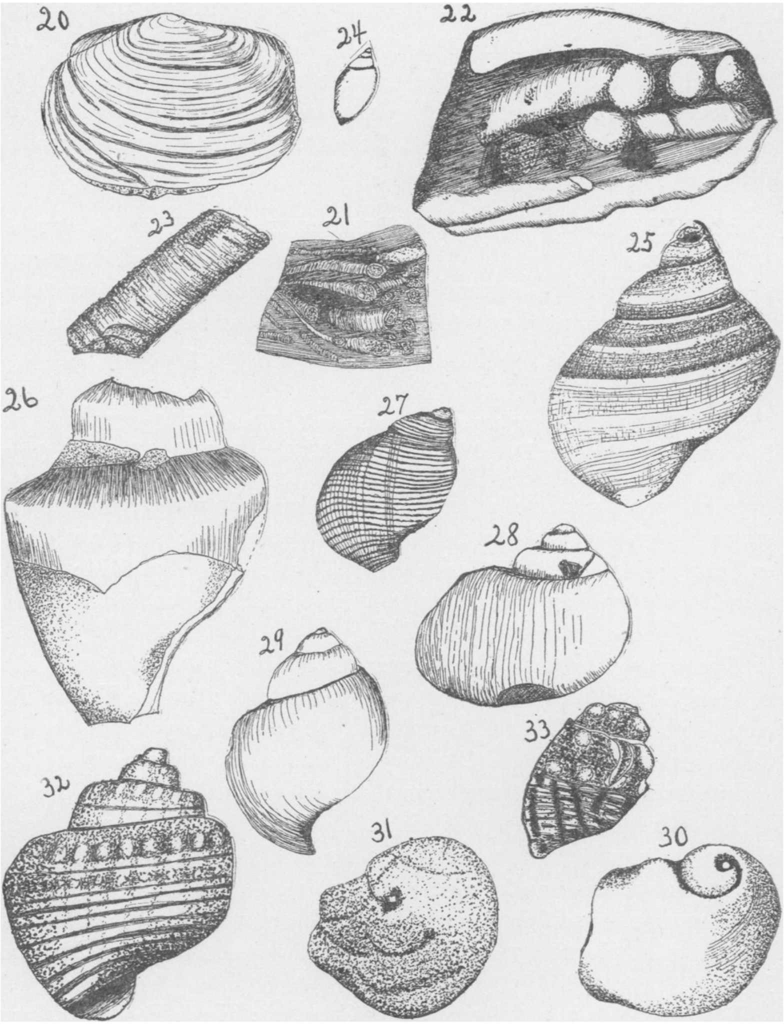

PLATE III.

Fig. 20. Panopea generosa Gould; times, one-half.
Fig. 21. Teredo species.
Fig. 22. Teredo bulbosus n. s.
Fig. 23. Dentalium substriatum Conrad.
Fig. 24. Olivella pedroana Conrad.
Fig. 25. Pisana clallamensis n. s.
Fig. 26. Chrysodomus gettysburgensis n. s.; a broken specimen.
Fig. 27. Purpura canaliculata Ducal; a somewhat distorted specimen.
Fig. 28. Polynices (Neverita) reclusiana Petit; times, one-half.
Fig. 29. Polynices (Lunatia?) olympidea n. s.
Fig. 30. Sigaretus scopulosus Conrad.
Fig. 31. Trochita inornata Gabb.
Fig. 32. Dolium petrosum Conrad; times, one-half.
Fig. 33. Dolium bileratum Conrad; a much distorted specimen.

its tabular area not being keeled and in its lack of sculpture. It differs from *C. giganteus* (described later) in its smaller size and in its not possessing the double tabular area and the keeled ridges bordering the respective tabular areas. A single specimen was obtained from the lower shales of the Oligocene-Miocene formation near Gettysburg, Wash.

Family LXI MURICIDÆ; Subfamily PURPURINÆ; Genus *Purpura* Brugiére.

Shell imperforate, oblong-oval, last whorl large with transverse ribs or nodes; spire generally short; aperture oval to ovate, large, terminating in a very short oblique channel, or notched; columella flattened, smooth; outer lip simple. *Purpura persica* Linne is a characteristic species.

27. *Purpura canaliculata* Ducal. Plate III, fig. 27.

Purpura canaliculata Ducal, An. N. Sc., 1832, p. 104, pl. LI, fig. 1 (equals *P. lima* Martyn).

Shell small, semiglobular; spire somewhat elevated; whorls four; suture impressed distinct; body whorl ventricose; aperture elliptical, large; inner lip flattened; canal short; outer lip thin; surface ornamented with spiral ridges and fine incremental lines (mostly worn off the specimens at hand).

Specimens of this species were found in the Gettysburg shale of the Clallam formation, but were rather rare; in the Upper Pliocene of the Quillayute formation, however, they are abundant. The specimens from the Clallam formation, however, have a larger body whorl than the more recent specimens.

This species is easily distinguishable from *P. crispata* by its larger body whorl in proportion to its axial length, and also by its smoother surface and by its smaller spire.

Measurements of a specimen from the clay shales of the Clallam formation of Gettysburg, Wash.: Axial length, 26; diam. 22; canal, 18 x 14.

Living: Alaska to San Diego (Cooper); Neah Bay, Quillayute Bay (Reagan).

Pliocene: Santa Rosa, Kirker's Pass, San Fernando, Cal. (Arnold); Quillayute, Wash. (Reagan); Queets, Wash. (Arnold).

Post-Pliocene: Santa Barbara (Gabb).

Oligocene-Miocene: Gettysburg, Wash. (Reagan).

The specimen figured is from the Quillayute formation.

Superfamily CERITHIACEA; Family LXXVII NATICIDÆ.
Genus *Polynices* Montfort.

All Naticida with corneous opercula. *Natica mammilla* is the type.

Subgenus *Neverita* Risso.

"Shell depressed, orbicular; spire conical or flattened; columella partly filled by a tongue-shaped callous process (funiculum) from the columella. *Natica duplicata* Say is a characteristic species."[47]

28. *Polynices (Neverita) recluziana* Petit. Plate III, fig. 28; times, one-half.

Natica recluziana Petit, Deshayes, Mag. de Zoöl., Mollusca, p. 37, 1841. Tryon, Man. Conch., vol. VIII, p. 34, pl. XII, fig. 1, 1886.

Neverita recluziana Petit, H. & A. Adams, Gen. Rec. Moll., vol. I, p. 208, 1853. Carpenter, Brit. Assn. Rept., 1863, p. 661. Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 254. Keep, West Coast Shells, p. 46, fig. 26, 1892. Williamson, Proc. U. S. Nat. Mus., vol. XV, 1892, p. 211.

Neverita recluziana Desh., Gabb, Pal. Cal., vol. II, p. 77, 1869. Dall, Trans. Wagner Inst. Sci., vol. III, part 2, 1892, p. 396.

Polynices (Neverita) recluziana Petit, Arnold, Mem. Cal. Acad. Sci., vol. III, 1903, pp. 314, 315, pl. X, fig. 12.

"Shell ovate to flattened globular; spire only slightly elevated, obtuse; whorls three, slightly convex, body whorl having a long, slightly convex slope from suture to near base, where it suddenly turns under the umbilicus; surface ornamented with fine, oblique incremental lines; suture distinct, but not impressed; aperture semilunar; lip thin; columella incrusted, the incrustation extending down, completely covering the umbilicus."[47]

Dimensions: Length, 45; lat., 48.

Many of the young of this species are quite flat, the spire but little elevated, if elevated at all. Var. *Alta* Dall is also found in the same formation with the *P.* (*Neverita*) *recluziana.* The species is very variable in both size and shape.

This species is found in both the upper and lower series of the Clallam formation at Gettysburg, Wash.

Living: Lower California to Monterey, Cal. (Cooper).

Pleistocene: Santa Barbara, San Diego, San Pedro, Cal. (Arnold); San Diego to Santa Barbara (Cooper).

Pliocene: San Fernando, Santa Barbara (Cooper); San Diego, San Pedro (Arnold); San Diego well (Dall).

Miocene: Walnut Creek, Martinez, Santa Monica, Santa Inez, Cal. (Cooper).

Oligocene-Miocene: Gettysburg, Clallam county, Washington (Reagan).

28½. *Polynices (Neverita) saxea* Con.

Natica saxea Con., Wilkes's Expl. Exped., vol. X, p. 727, pl. 19, fig. 7.

Neverita saxea Con., Jour. Conch., 1865, p. 51.

Shell small, subglobose; spire slightly elevated, but proportionately elevated more than the spire of *N. reclusiana;* spire obtuse to subacute; whorls five, convex; surface (a small patch of the shell covering still remaining on one of the casts) ornamented with wavy, oblique, incremental lines, some more prominent than their fellows; suture distinct; aperture semilunar to suboval.

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[47] Arnold, loc. cit.

This is a very common shell, running through all the series, both at Gettysburg and East Clallam.

Miocene: Oregon (Conrad).

Oligocene-Miocene: Gettysburg, East Clallam, Wash. (Reagan).

Subgenus *Lunatia* Gray.

Naticidæ with open umbilicus, without funiculum. Type, *Natica ampullaria* Lam.

29. *Polynices* (*Lunatia?*) *olympidii* n. s. Plate III, fig. 29.

Shell of medium size, ovate-globular; spire elevated, conic; whorls four, evenly convex, not shouldered; surface ornamented by fine, oblique incremental lines and by very faint revolving striæ on lower part of body whorl; suture distinct; aperture semilunar; outer lip sharp; inner lip incrusted; umbilicus open.

Dimensions: Axial length 26; lat. 20; aperture 15 x 10.

Distinguishable from *N. clausa* and *P. recluziana* in having a more elevated spire and in having its umbilicus open; and from *P. lewisii* in its smaller size, more elevated spire, its lacking the spiral groove, and by its having spiral striæ on the body whorl.

This species is found principally in the upper and lower series of the Clallam formation at Gettysburg, Wash. A few specimens resembling the type were seen at East Clallam.

Genus *Sigaretus* Lam.

Shell depressed, auriform, with minute spire and with aperture greatly distended; spirally striated or furrowed; whorls rapidly widening; color usually white, sometimes with a thin, corneous epidermis; operculum small, horny. *Sigaretus neritoideus* Linne is a characteristic species.

30. *Sigaretus scopulosus* Conrad. Plate III, fig. 30.

Sigaretus scopulosus Con., Wilkes's Expl. Exped., vol. X, p. 727, pl. 18, figs. 6, 6*a*, *b*, *c*.

Shell resembles *N. duplicata* Say very much, but is compressed and has the body whorl flattened a little on the upper part and also somewhat extended.

Shell flattened-globular, spire very slightly elevated, obtuse; whorls two and a half to three; whorls having a long, slightly convex slope from suture to near base, where it becomes a little rounded;

surface marked with numerous very fine, revolving lines; suture distinct; aperture semilunar; lip thin.

Dimensions: Longest diameter, 28; transverse diameter, 20; alt., 15; aperture in longest diameter, 22; transverse diameter, 19.5.

A single specimen of this species was obtained from the middle series at East Clallam.

Miocene: Astoria, Ore. (Conrad).

Oligocene-Miocene: East Clallam, Wash. (Arnold; Reagan).

Superfamily DOCOGLOSSA; Family LXXXIV TROCHIDÆ.
Genus *Trochita Schumacher.*

31. *Thochita inornata* Gabb. Plate III, fig. 31.

Irochita inornata Gabb (See Gabb, Pal. Cal., vol. II, 1869).

Shell irregularly depressed, low, conical, almost circular in outline; height two-thirds of width; volutions about two and one-half; suture indistinct to obsolete; surface of specimen entirely without ornamentation.

Dimensions: Diameter, 25; alt., 9.

The specimen obtained is from the lower series, East Clallam.

Miocene of California (Gabb).

Oligocene-Miocene: East Clallam, Wash. (Reagan).

Superfamily TÆNIOGLOSSA; Family DOLIIDÆ; Genus *Dolium* Lam.

Shell spirally ribbed; outer lip notched internally; canal short, obliquely directed.

32. *Dolium petrosum* Con. plate III, fig. 32; times, one-half.

Dolium petrosum Con., Wilkes's Expl. Expedition, vol. X, p. 722, pl. 19, figs. 3, 5.

Semiosis petrosus Con., Sm. Check List No. 474.

Dolipopsis petrosus Con., Jour. Conch., 1865, p. 150.

Shell large, subglobose to ovate globose in general outline; about a third higher than broad; whorls four or five in number; body whorl large and broadened at base by a broad reflected lip; spire moderately elevated; volutions distinct, carinated; surface marked by raised, rounded, revolving ribs, about twenty-one on the body whorl, with wide intervening grooves; the tenth and sixteenth spiral elevations are nodose, the nodes on the former being faintly shown, on the latter very pronounced, and the interspaces between the nodes continue as slightly depressed areas from base to apex of shell; shoulder angular, tuberculate, having a slightly concave space below the angle; also a revolving prominent line; aperture large; outer lip reflected.

By comparing the shell here described with the one in the geological collection of the Leland Stanford Junior University its spire was found to be less high.

Dimensions: Alt., 68; lat., 49; aperture, 44 x 30.

This species was found only in the clay shales near Gettysburg, Wash., by the writer. Mr. Arnold, however, found it represented in the sandstone that overlies these shales.

Miocene: Oregon (Conrad).

Oligocene-Miocene: Gettysburg, Wash. (Arnold; Reagan).

33. *Dolium biliratam* Con. Plate III, fig 33.

Dolium petrosum Con. (pars.), Wilkes's Expl. Exped., vol. X, p. 727, pl. 19, fig. 4.

Doliopsis biliratus Con., Jour. Conch., 1865, p. 150.

Semicosis? biliratus Con., Sm. Check List, 1866, No. 472.

The specimen obtained is much crushed longitudinally. It is a small shell and resembles the immature specimens of *Dolium petrosum* Con., but unlike them it has two revolving rows of large nodes on the body whorl; the ribs are also more elevated and more angular.

Dimensions: Alt., 19; diam., 14.

This specimen was obtained from the Oligocene-Miocene shales near Gettysburg, Wash.

Miocene: Astoria, Ore. (Conrad).

Oligocene-Miocene: Gettysburg, Wash. (Reagan).

SEA PLANTS.

?Macrocystis cf. pyrifera?.

The impressions of the stems of seaweed, doubtfully referred to the above genus, are often met with in the rocks of the Clallam formation, especially in the shale-bearing regions. They resemble the long, pipe-like tubes of the kelp so abundant in the strait adjacent at the present time.

A Compiled List of Fossils from the Clallam Formation (Oligocene-Miocene) Exposed Along the Strait of Juan de Fuca.

FOSSILS FROM THE GETTYSBURG SERIES.

Solemya ventricosa Conrad. (SL)
Solemya rubroradiata Conrad.
Leda sp.
Nucula (Acila) castrensis Hinds.
Nucula (Acila) gettysburgensis n. s.
Nucula sp.
Yoldia impressa Conrad. (SL)
Cytherea cf. vespertina Conrad. (SL)
Pecten clallamensis Arnold.

Pecten waylandi. Arnold.
Thracia cf. trapezoides Conrad. (SL?)
Thracia trapezoides Conrad.
Phacoides acutilineatus Conrad. (SL, SM)
Venus (Chione) vespertina Conrad.
Venus (Chione) angustifrons Conrad. (SL, M)
Venus (Chione) mathewsonii Gabb. (VM)
Venus (Chione) temblorensis Anderson.
Tellina sp.
Tellina (Angulus) sp.
Tellina albaria Conrad.
Mactra gibbsana Meek.
Dentalium substriatum Conrad.
Fusus sp.
Marginella or Erato sp.
Natica sp.
Polynices (Neverita) recluziana) Petit. (C)
Polynices (Neverita) saxea Conrad. (SL)
Polynices (Lunatia?) olympidii n. s.
Cyrodes aff. dowelli White.
Trochita inornata Gabb.
Olivella pedroana Conrad. (V, SP)
Perissolax sp.
Pleurotoma sp.
Scala sp.
Dolium petrosum Conrad. (M?)
Dolium bileratum Conrad.
Chrysodomus gettysburgensis n. s.
Cylichna petrosa Conrad.
Purpura canaliculata Ducal. (SP)
Aturia cf. ziczac Sowerby. (SL)
?Macrocystis cf. pyrifera?.

FOSSILS FROM THE EAST CLALLAM-NEAH BAY SERIES.

Leda sp.
Nucula sp.
Nucula (Acila) castrensis Hinds.
Nucula (Acila) gettysburgensis n. s.
Yoldia impressa Conrad. (SL)
Yoldia sp.
Arca sp.
Pectunculus patulus? Conrad.
Mytilus aff. mathewsonii Gabb.
Panopea generosa Gould. (SL?, V?)
Phacoides acutilineatus Conrad. (SL, V, SM)
Phacoides cf. nuttallii Conrad.
Cardium aff. quadrigenarium Conrad.
Venericardia sp.
Thyasira bisecta Conrad.
Venus (Chione) angustifrons Conrad. (SL, M)
Venus (Chione) aff. temblorensis Anderson.

Venus (Chione) olympidea n. s.
Venus (Chione) clallamensis n. s.
Cytherea cf. vespertina Conrad.
Saxidomus gibbosus Gabb. (V)
Pecten fucanus Dall?.
Pecten fucanus Dall.
Pecten propatulus Conrad.
Pecten (Chlamys) wattsi, var. morani Arnold?.
Tellina sp.
Tellina arctata Conrad. (SL?)
Tellina arctata, var. Juana n. var.
Tellina aff. bodegensis Hinds. (V?)
Tellina clallamensis n. s.
Metis alta Conrad.
Mactra gibbsana Meek.
Mactra sp. (C. and N. B.)
Teredo sp.
Teredo bulbosus n. s.
Dentalium sp.
Dentalium substriatum Conrad.
Crepidula praerupta Conrad. (SL?)
Fúsus oregonensis Conrad. (SL)
Fusus sp. (C. and N. B.)
Scala (Opalia) sp.
Natica sp.
Polynices (Neverita) saxea Conrad. (SL)
Polynices (Lunatia?) olympidii n. s.
Sigaretus scopulosus Conrad. (SL, V)
Trochita inornata Gabb.
Pisiana clallamensis n. s.
Cancillaria sp.
Cylichna sp.
?Macrocystis cf. pyrifera ?

The species marked in the two lists above are also found in the Tertiary formations of California, as follows: (SL), San Lorenzo formation (Oligocene); (V), Vaqueros sandstone (Lower Miocene); (M), Monterey shale (Middle Miocene); (C), Carrizo Creek beds (Miocene); (SP), San Pablo formation (Upper Miocene); (SM), Santa Margarita formation (Upper Miocene).[48]

Lists of Fossils from Other Localities on the Pacific Coast Added for Correlation.

Species followed by (S) are found among the Gettysburg fossils; those by (SC) are represented in the East Clallam-Neah Bay series; those marked (S, SC) are represented in both series.

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[48] See Arnold's list of California fossils in Professional Paper No. 47, pp. 17-24.

FOSSILS FROM VANCOUVER ISLAND.

List from Carmanah Point (Miocene).[49]

Nucula divaricata Con. (S, SC)
Lucina acutilineata Con. (S, SC)
Mya abrupta Con.
Tellina oregonensis Con.
Crpeidula rostralis Con. (SC)
Dentalium substriatum Con. (S, SC)
Cerithiopsis oregonensis Con.
Priscofusus oregonensis Con.
Cardita ventricosa Gld.
Tellina albaria Con. (S)
Pectunculus patulus Con. (SC?)
Lunatia oregonensis Con. (S, SC)
Sinum scopulosum cf. Con. (SC)
Cylichna oregona Con. (S)
Loripes parilis Con.
Cytherea aff. vespertina Con. (S, SC)
Trochita aff. inornata Gabb. (SC)
Mytilus edulis Linn. (aff.)
Turritella, nov. sp.
Cardium, nov. sp.
Cytherea sp.
Solen sp.
Axinus bisectus Con. (SC)
Chrysodomus sp.
Venus pertonuis Gabb.
Veneroid (possibly Clementia).
Macoma nasuta Con.
Pachypoma biangulata Gabb (conf).
Mytilus cf. edulis Linn.
Pleurotoma indent.
Teredo sp.

List from the Sooke District[50] *(Middle Miocene).*

Placunanomia macroschisma Desh.
Mytilus edulis Linn.
Cerithidæ californica Hald.
Acmæa mitra Esch.
Crepidula rugosa Nutt (aff.).
Pecten æquisulcatus Carp. (conf.).
Pecten hostatus Sowb. (conf.).
Chrysodomus dirus Reeve.
Yoldia impressa Con. (S, SC)
Pectunculus patulus Con. (SC?)
Trochita inornata Gabb. (SC)
Sinum scopulosum Con. (conf.). (SC)
Fusus nov. sp. (a).
Fusus nov. sp. (b).

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[49] Merriam, Univ. Cal. Geol., vol. 2, No. 3, pp. 103-104.
[50] Merriam, loc. cit., p. 106.

Patelloid nov.
Massa (?) nov. sp.
Ancillaria nov. sp.
Cytherea nov. sp. (a).
Cytherea nov. sp. (b).
Bittium nov. sp. (?).
Crepidula sp.
Ostrea sp.
Cardium sp.
Tapes (?) sp.
Cerithidea sp.

FOSSILS FROM THE PUGET GROUP (LARAMIE ?) OF KING AND PIERCE COUNTIES, WASHINGTON.[51]

Cardium (Adacna?) ?
Cyrene brevidens White.
Corbicula willisi White.
Corbicula pugetensis White.
Batissa newberryi White.
Batissa dubia White.
Psammobia obscura White.
Sanguinolaria? caudata White.
Teredo pugetensis White.
Neritina —?.
Cerithium —?.
Undetermined gasteropod.

FOSSILS FROM THE OREGON (ASTORIA) MIOCENE OF CONRAD.

Crustacea.

Calianassa oregonensis Dana.

Mollusca.

Mya abrupta (Panopea estrellana) Con.‡ (182).
*Solen curtis (Ensis curtus) Con.[52]
Thracia trapezoides Con. (S)
Solemya ventricosa Con. (S)
Donax? protexta (Hypogella protexta) Con.† (89).
Venus bisecta Con. (Thyasira bisecta) Con.‡ (135), also Wilkes's Exped. (SC)
Venus (Chione) angustifrons Con. (S, SC)
Venus lamellifera Con.
*Cytherea vespertina (Venus (Chione) vespertina) Con.† (118) (S, SC?)
Venus brevilineata (Venus (Chione) succinta Val.) Con.‡ (149).
Cytherea oregonensis (Venus (Chione) oregona) Con.† (95); also,.
Lucina acutilineata (Phacoides acutilineatus) Con.‡ (132) (S, SC)
Tellina arctata Con. (SC)
Tellina emacerata (Tellina bodegensis Hds.) Con.† (92).
Tellina albaria Con. (S)

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[51] White, Bull. U. S. Geol. Surv., No. 51, p. 58.

[52] The species preceded by * are to be found described by Conrad in the *American Journal of Science*, vol. LV, 1848, pp. 432, 433, figs. 1–14. The species not preceded by the * are described by Conrad in Wilkes's Exploring Expedition, vol. X, pp. 722–730, pls. 17–20. The revised names followed by † are found in Gabb, Pal. Cal., vol. II, 1869, page indicated in the parentheses. And those followed by ‡ are found in Arnold, Mem. Cal. Acad. Sci., vol. III, 1903, page likewise indicated in the parentheses.

*Tellina oregonensis Con.
*Tellina obrupta Con.
Tellina nasuta (Macoma nasuta) Con.† (93).
Tellina bitruncata Con.
*Nucula abrupta (Neilo abrupta) Con.† (122).
Nucula divaricata (Nucula castrensis Hds.) Con.† (102) (S, SC)
*Nucula cuneiformis Con.
Nucula impressa (Yoldia impressa) Con.† pars. (102) (S, SC)
*Nucula penita Con.
Pectunculus patulus (Glycymeris patula) Con. (SC?)
Pectunculus nitens Con.
Arca devincta Con.
Arca.
Cardita subtenta (Venericardia ventricosa Gld.) Con.† (128).
Pecten propatulus Con. (SC)
Terebratula nitens Con.
Dolium petrosum Con. (S)
Dolium biliratum Con. (S)
Sigaretus scopulosus Con. (SC)
Natica saxea (Neverita saxea; Lunatia oregonensis) Con.† (see Gabb.) (S, SC)
Bulla petrosa (Cyclichna oregona and petrosa) Con. (S)
*Pyrula modesta (Ficopsis modesta) Con.† (113).
Crepidula prærupta Con. (SC)
Crepidula?.
Rostellaria indurata Con.
Cerithium mediale (Priscofusus medialis) Con.† (112).
Buccinum? devinctum (Priscofusus devinstus) Con.† (112).
Fusus geniculus (Priscofusus geniculus) Con.† (71).
*Fusus oregonensis (Tritonium oregonensis) Redfield† (73).
Fusus corpulentus (Priscofusus corpulentus) Con.† (112).
Natilus angustatus (Aturia ziczac Sby.) Con.† (69). (S)
Teredo substriatum (Dentalium substriatum) Con.† (115). (S, SC)
Turritella sp.
Territella sp. (No. 2).
Foraminifera.

Radiata.

Galerites oregonensis Dana.

Plants.

Abies robusta Dana.

From the above lists it is found that the fossils of the Clallam formation are only slightly related to the Miocene of California, but more related to the Oligocene of that state, there being eight species of the Gettysburg fossils represented in it and nine of the East Clallam-Neah Bay fossils, four of which are found both at East Clallam and at Gettysburg; or, to consider the formation as a whole, thirteen fossils are found to be common in the two formations, though some are doubtfully so considered. But not an Eocene fossil of California is represented in the Clallam formation, as is also the case with the fossils of the Puget group of Washington. To review the Astoria (Oregon) Miocene list of Conrad, fourteen fossils of the Gettysburg series are represented in it and thirteen fossils of the Clallam-Neah Bay series, seven of which are also found at Gettysburg, making for the Clallam formation, as a whole, twenty species identical with those of the Astoria formation. To carry the correlation to the Tertiary fossils of Vancouver Island, it is found that of the fossils of the Sooke District only four are represented in the fossils of the Clallam formation, but the fossils of Carmanah Point have a better ratio. Ten are found to be identical. Also the Clallam-Neah Bay fossils are found to be more nearly related to the Carmanah Point fossils than those at Gettysburg, the ratio being ten to six; but the fossils of the whole formation are more related to the Astoria Miocene. It therefore seems that the age of the Clallam formation is practically the same as that of the Astoria formation.

GENERAL REMARKS.

Pliocene.—In Pliocene times the lower courses of practically all the streams flowing into the Pacific, and also of the Hoko and Clallam rivers, flowing into the strait, were submerged. In addition, the great synclinal trough reaching from the mouth of the Suez river and Waatch strait eastward far into the Bogachiel country, and practically from the coast northward nearly to the westward extension of the Olympic axis, was covered with a deep sea, so that whales made it their playground. Then at the close of the epoch most of the region was elevated above the sea, all on the Pacific side to be submerged again in the Pleistocene. The distinct formations represented in the region are as follows:

Hoko Formation.—A series of conglomerates occupy the territory from the Hoko river in its lower course eastward to Clallam Bay, and is seen to rest unconformably upon the upturned and eroded sandstones and shales of the Clallam formation. The boulders of this formation were seen to contain Miocene fossils. The formation certainly being pre-Pleistocene, the above evidence locates it with certainty in the Pliocene (Arnold). Its thickness is approximately 300 feet.

Raft River Formation.—An outcrop on the north side of the mouth of Raft river contains concretionary sandstone and gray shale, which Doctor Arnold considers an equivalent of a portion of the Quinaielt formation, described next below.

Quinaielt Formation.—Doctor Arnold's description (in part):[53]

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[53] Geological Reconnaissance of the Olympic Peninsula, Washington, Bull. Geol. Soc. Am., vol. 17, p. 465.

This formation occupies "a great syncline between capes Elizabeth and Granville, through the trough of which the Quinaielt river empties into the sea. The formation in which this syncline is developed is therefore termed the Quinaielt. The Quinaielt consists of over 2200 feet of conglomerates and shales, with minor quantities of sandstone. The conglomerates are developed on the north of the river, while the shale, with some underlying sandstone, occurs south of it. Owing to the fact that faults limit the syncline on both sides, it is impossible to determine positively which facies of the formation, the conglomerate or the shale, was the older. However, it appears most likely that the latter represents the basal portion of the formation. The beds contain well-preserved marine fossils, and the conglomerates in particular considerable quantities of almost unaltered wood and bark of trees, often in large fragments." The fossils from this formation, listed below, make it contemporaneous in age with the Purisima formation of central California.

Quillayute Formation.—This formation occupies the valley of the Quillayute river and the country drained by its eastern tributaries eastward at least to their respective middle courses, thence westward to Waatch strait, the formation extending outward to the coast now and then. The boundaries of the formation were not ascertained. In the interior region, where exposed along the Bogachiel river, it is composed of sandstone and bluish-gray shale; the coast exposures are all conglomerates or a coarse gravelly rock resting unconformably upon the older rocks exposed there. The base of the formation was not seen in the interior region. The thickness of the formation, consequently, was not ascertained The sandstone series was found to be extremely fossiliferous, and in it the fossils are beautifully preserved. Fossils were found at two horizons—in the north bank of the Bogachiel river in a bluish-gray rock in section 22, township 28 north, range 14 west of the Willamette meridian, and in the bluff south of the abandoned channel of Maxfield creek on the south side of the Bogachiel river, in sections 28 and 29 of the township and range above. But fossils were obtained only from the latter location, as the former was below the surface of the water of the river at the time visited. Below is a description of the fossils obtained.

Fossils of the Quillayute Formation (Lower? Pliocene) Exposed in the Vicinity of Quillayute, Wash.

The only Pliocene fossils so far mentioned in the state, so far as the writer can learn, are those of the Quinaielt formation, some sixty miles south of Quillayute, down the coast. The age of the formation is the same as that of the Purisima formation (Lower Pliocene) of Central California (Arnold). For comparison, Doctor Arnold's list of fossils from this formation is given side by side with the list of fossils obtained at Quillayute by the writer, as both lists are from the Olympic Peninsula.

PLIOCENE FOSSILS FROM THE OLYMPIC PENINSULA, WASHINGTON.

Fossils from the Quillayute formation.	*Doctor Arnold's list from the Quinaielt formation.*
Scutella sp.	
(M, P)*Nucula castrensis Hinds.	
	Leda sp. (short and smooth).
Yoldia cooperi Gabb.	Yoldia cf. cooperi Gabb.
	Lima cf. hamlini Dall.
(M?, P?)*?Phacoides acutilineatus?.	
(P?) Phacoides nuttallii?.	
(M, P) Cardium meekianum Gabb. (*)	
(M) Cardium (Ceratoderma) corbis Martyn.	
Tivila crassatelloides Conrad.	
*Venus (Chione) matthewsonii Gabb. (*)	
(M, P) Tapes staleyi Gabb. (*)	Tapes cf. staleyi Gabb.
(M, P) Macoma inquinata Deshayes.	Macomo sp.
Tagelus californicus Conrad.	
(M, P) Solen sicarius Gould.	Solen sicarius Gould.
(M, P) Mactra californica Conrad.	Mactra sp.
Mactra exoleta Gray.	
(P) Mactra hemphilli Dall. (*)	
(P) Mactra (Spisula) catilliformis?.	
(M, P) Mactra (Spisula) falcata Gould.	
Mya truncata Linn. (*)	
(M, P)*Panopea generosa Gould.	
	Pecten hastatus var. hericius Gould.
	Thracia trapezoides Conrad.
	Anachis sp.
Cylichna alba Brown.	Cylichna sp.
	Margarita sp.
(M, P) Pleurotoma perversa Gabb.	Pleurotoma perversa Gabb.
(M) Bela fidicula Gould. (*?).	
Bela sanctæ monicæ Arnold? (*)	
(M)*Olivella pedroana Conrad.	
Buccinum bogachielii n. s.	
Chrysodomus giganteus n. s. (*)	Chrysodomus aff. tabulatus Baird.
Chrysodomus stantoni Arnold.	
Neptunea maxfieldii n. s. (*)	
(M) Monoceros engonatum Conrad.	
Trophon sp.	
	Opalia cf. borealis Gould.
	Priene aff. oregonensis Redfield.
(P) Purpura crispata Chemnitz.	Purpura crispata Chemnitz.
Purpura lapillus Lam.	
Purpura lapillus var. quillayutea n. var.	
(M)*Purpura canaliculata Duclos.	Purpura canaliculata Duclos.
	Purpura saxicola Valenciennes.
	Solariella peramabilis Carpenter.
Eulima washingtoni n. s. (*)	
Ranella marshallii n. s. (*)	
Aporrhais (Arrhoges) quillayutensis n. s. (*)	
(M, P) Natica (Cryptonatica) clausa Broderip & Sowerby.	Natica clausa Broderip & Sowerby.
(M, P) Polynices (Lunatia) lewisii Gould.	
Whale-ribs.	

By comparing the above lists it is found that only five species are common to both formations. It is also found by comparing the Quillayute list with lists of living species that about two-thirds of the species given in it are living at the present time, six of which are now living in Quillayute Bay adjacent.[54] The fossils that are supposed to be extinct are followed by a *.

The species in the Quillayute list above that are preceded by a * have been described in the Oligocene-Miocene fossils, to which the reader is referred for a description of each. The other Quillayute fossils are described below.

The species preceded by (P) are also found in Purisima-San Diego (Lower Pliocene) formation of California, and those marked (M) are found in the Merced-Deadman Island (Upper Pliocene) of the same state. It is thus seen that sixteen fossils from the Purisima-San Diego formation, two doubtfully so classed, and seventeen from the Merced-Deadman Island formation are found in the Quillayute formation.[55] Also, by comparing Doctor Arnold's Pleistocene lists with the lists from this formation, it is found that twenty of the fossils are common.[56] The percentage, therefore, seems to favor an Upper Pliocene for the age of the Quillayute formation. And again, a like percentage of the fossils are represented in the Miocene. Consequently, this would seem to place the formation at the base of the Pliocene. Following is a description of the fossils:

ECHINODERMATA.

Class II ECHINOIDEA; Sub-branch III EUECHINOIDEA.
Order IV CLYPEASTROIDA; Family 3 SCUTELLIDÆ; Genus *Scutella* Lam.

Scutella sp.

The inside cast of a specimen of this genus was found in the Quillayute formation at the abandoned mouth of Maxfield creek, near Quillayute, Wash.

MOLLUSCA.

Class PELECYPODA; Order PRIONODESMACEA.
Superfamily NUCULACEA; Family VI LEDIDÆ; Genus *Yoldia* Möller.

Shell oblong, slightly attenuated behind; compressed, gaping, smooth or obliquely sculptured with a dark-olive, shining epidermis; external ligament slight; hinge as in *Nucula* and *Leda;* pallial sinus deep. (After Arnold.)

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[54] See Reagan, "Some Sea Shells from La Push, Wash." Trans. Kan. Acad. Sci., vol. XXI, part I, 1907, pp. 168-177.

[55] See Professional Paper No. 47, pp. 28-32.

[56] Loc. cit., pp. 33-37.

34. *Yoldia cooperi* Gabb. Plate IV, fig. 34.

Yoldia cooperi Gabb, Proc. Cal. Acad. Sci., vol. III, 1865, p. 189; Pal. Cal., vol. II, 1869, p. 31, pl. IX, fig. 54; Williamson, Proc. U. S. Nat. Mus., vol. XV, 1892, p. 192; Dall, Trans. Wagner Inst. Sci., vol. III, 1898, p. 594; Arnold, Mem. Cal. Acad. Sci., vol. III, pp. 99, 100. In part, Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 270; also, in part, Gabb (*fide* Pal. Cal., vol. II, 1869, p. 59).

Shell thin, oblong, very inequilateral, subcompressed; anterior end subaccuminate, pointed, concave above; posterior end broadly rounded; posterior ventral margin meeting the posterior extremity in a broad, rounded curve, from which it continues broadly arcuate to about opposite the beak, when it curves rapidly upward to the anterior end; beaks minute and placed in advance of the middle; surface sculptured by numerous small concentric ribs, which are less abrupt on the upper side and slope downward on the side towards the base; hinge with numerous sharp teeth; inside of shell not seen.

Dimensions of medium-sized mature specimen: Lat., 58; alt., 29; umbo to anterior extremity, 17; to posterior extremity, 37.

Dimensions of largest specimen figured: Lat., 58; greatest alt., 32; from umbo to posterior extremity, 40; to anterior extremity, 22.

This species is quite variable, depending upon the age. It differs from *Y. impressa* Con. (Wilkes's Exped.) in its much greater length and altitude and in its being more compressed.

Living: Half Moon Bay, California (Arnold); San Diego to Santa Sruz (Cooper).

Pleistocene: Ventura, San Diego, Cal. (Arnold); San Pedro (Arnold; Cooper).

Pliocene: San Fernando (Cooper); Portata Valley, California (Arnold).

? Pliocene: Mouth of Quinaielt river, Granville, Wash. (Arnold); Quillayute, Wash. (Reagan).

Order TELEODESMACEA; Superfamily CARDIACEA.
Family XXVI CARDIIDÆ; Genus *Cardium* (Linné) Lamarck.

Shell cordate, inflated, variously sculptured, usually striated or radially ribbed, usually closed but sometimes slightly gaping; beaks prominent; lunule or escutcheon absent; pallial line distant from margin of the valves.

35. *Cardium meekianum* Gabb. Plate IV, fig. 35; times, one-half.
Cardium meekianum Gabb, Pal. Cal., vol. II, p. 27, pl. 7, fig. 46, 1869.

Gabb's description (in part): "Shell large; beaks large, strongly incurved and pointed forwards; shell broadly rounded anteriorly and very oblique and abruptly truncated posteriorly; surface marked by twenty-two radiating ribs, which are acute in young shells, becoming rounded as they increase in size, and ultimately becoming distinctly flattened on top; these are crossed by irregular, curved, subsquamose plates, which, toward the beaks, lose their lamular character and are represented by little tubercles; posterior face of shell costate, but the ribs are less prominent; the interior spaces between the ribs are narrow and usually flat, though some are concave."

Dimensions of largest specimens obtained: Alt., 73; lat., 67; diam. of right valve, 19.

This is quite a numerous species in the Pliocene at Quillayute, Wash.

Pliocene: Humboldt county, California (Gabb); Quillayute, Wash. (Reagan).

Subgenus *Cerastoderma* Mörch.

Shell rotund or obovate, with strong ribs obsoletely granulore or intricate or smooth; no posterior or anterior area; channels single; hinge normal (Arnold).

36. Cardium (Cerastoderma) corbis Martyn. Plate IV, fig. 36.

Cardium corbis Mart., *Pectunculus corbis* Mart., Univ. Conch., pl. XXVIII, fig. 2, p. 1784. Carpenter, Brit. Assn. Rept., 1863, p. 642; equals *C. californicum* Con. and *C. nuttallii* Con. (see Gabb, Pal. Cal., vol. II, p. 98, 1869). Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 232. Keep, West Coast Shells, p. 180, fig. 53, 1892. Dall, Trans. Wagner Inst. Sci., vol. III, part 5, 1900, p. 1093. Arnold, Mem. Cal. Acad. Sci., vol. III, p. 140, 1903.

Shell very variable, large, subtrigonal, ventricose; umbones prominent, anterior; surface ornamented with about thirty to thirty-seven regular, slightly squarish, close set, radiating ribs, which are occasionally rugose, the ridges being less rounded near the posterior margin; inter-rib spaces channel-like grooves; margin crenulated; interior not seen.

Dimensions: Alt., 38.5; lat., 35; diam., 24.

Three specimens of this species were found on the north bank of the Bogachiel river in the Pliocene formation near Mr. Earl Wilson's homestead, some five miles southeast of Quillayute post-office.

Living: Kamchatka, Santa Barbara to Kodiac (Cooper).

Pleistocene: San Francisco, San Pedro, Monterey (Cooper); Santa Barbara, San Pedro (Arnold).

Pliocene: North bank of Bogachiel river, near Mr. Earl Wilson's homestead, Quillayute, Wash. (Reagan).

Superfamily VENERACEA; Family XXVII VENERIDÆ.
Subfamily VENERINÆ; Genus *Tivela* Link.

"Shell triangular, subequilateral, cuneiform; three to five cardinal teeth in one valve, four to six in the other; anterior lateral tooth narrow, elongated, compressed; pallial impression with a short oblique or sometimes horizontal sinus."[57]

37. *Tivela craisatelloides* Conrad. Plate IV, fig. 37; times, one-half.

Cytherea (*Trigonella*) *crassatelloides* Con., Jour. Phil. Acad. Sci., vol. VII, 1837, p. 253, pl. XIX, fig. 17. Hinds, Voyage Sulphur, p. 65, pl. XXI, fig. 1, 1844; equals *Donax stultorum* Marve, Linne, Lyst. Conch., pp. 37, 40, pl. IX, fig. 7, 1823; equals *D. stultorum* Mar., Gray, Index, Test. Suppl., pl. II (Donax), fig. 2, 1828.

Cytherea crassatelloides Con., Hanley, Descr. Cat. Rec. Bivalve Shells, p. 106, 1843. Sowerby, Thes. Conch., vol. II, p. 612, pl. CXXVII, figs. 1-3. Reeve, Conch. Icon., vol. XIV, pl. I, fig. 3, 1864; equals *Cytherea stultorum* Gray, Hanley, Descr. Cat. Rec. Bivalve Shells, p. 106, 1843; equals *Trigonella crassatelloides* Con., Jour. Phil. Acad. Sci., vol. I, 1849, p. 213; equals *Trigonia stultorum* Gray, Deshayes, Cat. Conch. Coll. B. M., part I, p 46, 1853; also *Trigonia crassatelloides* Con., Deshayes (loc. cit.); equals *Cytherea solodissima* Phil. Gabb, Pal. Cal., vol. II, p. 96.

Pachydesma crassatelloides Con., Proc. Phil. Acad. Sci., 1854, p. 121. Carpenter, Brit. Assn. Rept., 1863, p. 640. Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 256. Keep, West Coast Shells, p. 189, fig. 62. *Tivela crassatelloides* Con., Williamson, Proc. U. S. Nat. Mus., vol. XV, 1892, p. 187; equals *Cytherea* (*Tivela*) *crassatelloides* Con., Stearns, Proc. U. S. Nat. Mus., vol. XXI, 1898, pp. 371-378, pls. XXIII-XXV; also Nautilus, vol. XIII, 1899, p. 73. Arnold, Mem. Cal. Acad. Sci., vol. III, p. 143, 1903.

Shell large, thick, almost equilateral-triangular in shape, ventricose; umbones subcentral to slightly anterior to center, not very prominent; anterior dorsal margin straight to near middle transverse line of shell, rather equally rounded at base; posterior margin sharp, nearly straight; posterior extremity more obtusely rounded than anterior (in some cases it is almost angular); ventral margin elliptically to prominently and evenly arcuate; surface sculptured with very fine to very coarse incremental lines according to age of specimen; a posterior submarginal angular ridge is shown on some specimens, but is nearly or entirely obsolete in old specimens; cartilage-pit triangular, not wide, rather deep, separated from posterior ligamental groove by a prominent thick ridge; cardinal ridges (teeth) three in number, prominent, thick, anterior lateral tooth elongated.

Dimensions of medium-sized mature specimen: Lat., 96; alt, 80; diam., 37; umbones to anterior extremity, 69; to posterior extremity, 72.

The specimens of this species obtained differ from the Mactras in being more equilateral-triangular in shape, by being less gib-

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57. After Arnold (see below).

bous when mature, and by their having a thick shell and heavy cardinal teeth. They also differ from the living *T. crassatelloides* in having their beaks more central.

A very abundant species in the Quillayute Pliocene.

Living: San Diego to Santa Cruz, Cal. (Cooper).

Subfamily TAPETINÆ.

38. *Paphia* (*Tapes*) *statleyi* Gabb. Plate IV, figs. 38*a*, *b*, *c*.

Dosinia staleyi Gabb, Pal. Cal., vol. II, p. 24, pl. 7, fig. 42.

Tapes staleyi Gabb, Pal. Cal., vol. II, 1869, p. 57, pl. 16, figs. 17, 17*a*.

Shell large, subcircular, convex, thick, very inequilateral; beaks large, prominent, anterior, and turned forward; lunule faint, rather large, slightly sunken; hinge same as *Tapes staminea;* surface sculpture also same as *T. staminea*, except that the ribs and frills are at least four times as numerous as in that species; pallial sinus very deep and rather narrow.

This is a very abundant species in the Pliocene at Quillayute; Wash.

Very common in the Tertiary of California (Gabb).

Pliocene: Quillayute, Wash. (Reagan).

Superfamily TELLINACEA; Family XXX TELLINIDÆ.

Genus *Macoma Leach;* Sungenus *Macoma* s. s.

Shell subtrigonal, smooth, usually colorless; anal siphon long; brachial siphon very short; pallial sinus coalescent with the pallial line below; hinge without laterals; inhabiting the cooler seas, and especially boreal waters.

39. *Macoma inquinata* Deshayes. Plate IV, fig. 39.

Tellina inquinata Desh., Proc. Zool. Soc. 1854, p. 357.

Macoma inquinata Desh., Carpenter, Brit. Assn. Rept., 1863, p. 89. Gabb, Pal. Cal. vol. II, p. 93, 1869. Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 248. Keep, West Coast Shells, p. 195, 1892. Dall, Trans. Wagner Inst. Sci., vol. III. part 5, 1900, p. 1053. Arnold, Mem. Cal. Acad. Sci., vol. III, p. 162, 163, pl. XVI, fig. 4, 1903.

Shell suboval, convex, equivalve; umbones subcentral; posterior end evenly arcuate from umbo and acutely rounded from about half way between dorsal and ventral margins to posterior extremity; anterior end rather prominently dilated, especially so in front of umbo of right valve; interior of shell not seen.

Demensions of right valve of the largest and most perfect specimen obtained: Lat., 42; alt., 34; diam., 14; from umbo to posterior extremity, 29; to anterior extremity, 31.

This species is rare in the Quillayute formation, represented at the mouth of Maxfield creek, near Quillayute.

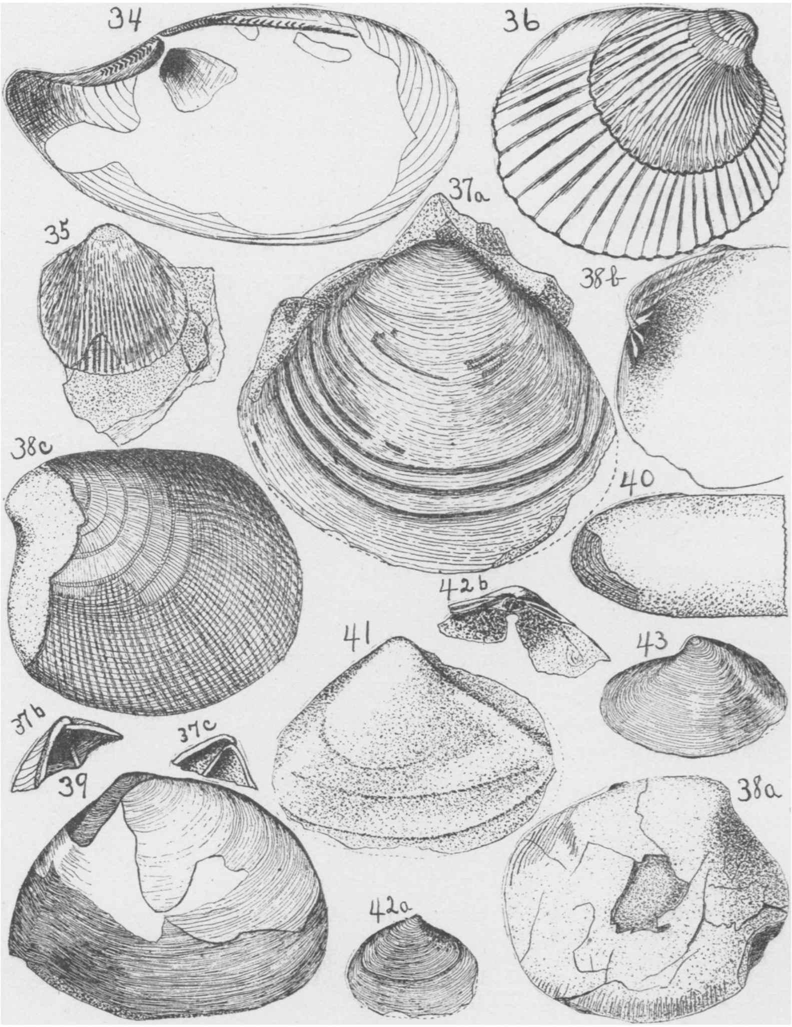

PLATE IV.

Fig. 34. Yoldia cooperi Gabb; a broken left valve, showing hinge of right valve.
Fig. 35. Cardium meekianum Gabb; cast of young specimen.
Fig. 36. Cardium (Cerastoderma) corbis Martyn.
Fig. 37*a*. Tivela crassatelloides Conrad; times, one-half.
Fig. 37*b*, 37*c*. Hinges of *T. crassatelloides?* specimens.
Fig. 38*a*. Paphia (Tapes) stalyi Gabb; a cast.
Fig. 38*b*. Hinge of 38*a*, above.
Fig. 38*c*. Drawing showing outside of valve of another specimen of the same species as 38*a*, above.
Fig. 39. Macoma inquinata Deshayes.
Fig. 40. Tegalus californicus Conrad; a much broken specimen.
Fig. 41. Mactra californica Conrad; a cast; times, one-half.
Fig. 42*a*. Mactra exoleta Gray.
Fig. 42*b*. Drawing of a broken valve of the same species, showing hinge. Both specimens are immature shells.
Fig. 43. Mactra hemphilli Dall; an immature shell.

Living: Alaska to San Diego (Cooper); Quillayute Bay, Washington (Reagan).

Pleistocene: San Pedro, Cal. (Arnold); San Diego to Monterey (Cooper).

Pliocene: San Fernando, Twelve Mile House, California (Cooper); Quillayute, Wash. (Reagan).

Family XXXII PSAMMOBIIDÆ; Genus *Tagelus* Gray.

40. *Tagelus californianus* Cont. Plate IV, fig. 40; times, one-half.

Only a fragment of a specimen of this species was obtained.

It was found among the *Mactra* shells of the Quillayute formation from the old mouth of Maxfield creek.

Superfamily MACTRACEA; family XXXV MACTRIDÆ.
Subfamily MACTRINÆ; Genus *Mactra* Linne.

"Shell nearly equilateral; anterior hinge tooth A-shaped, with sometimes a small laminar tooth close to it; lateral tooth doubled in right valve; ligament set off by a shelly lamina rising between chondrophore and ligament; cardinals generally coalescent above: laterals smooth or finely granular."[58]

Type, *Mactra stultorum* Linne.

41. *Mactra californica* Conrad. Plate IV, fig. 41; times, one-half.

Mactra californica Con., Jour. Phil. Acad. Sci., vol. VII, 1837, p. 240, pl. XVIII, fig. 12; Williamson, Proc. U. S. Nat. Mus., vol, XV, 1892, p. 187; Dall, Trans. Wagner Inst. Sci., vol. III, part 4, 1898, p. 876; Arnold, Mem. Cal. Acad. Sci., vol. III, pp. 174-176, pl. XIX, fig. 2, 1903.

Standella californica Con., Carpenter, Brit. Assn. Rept., 1863, p. 640; Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 265.[59]

"Shell of medium size, subtrigonal, subequilateral, compressed, thick; umbones subcentral, turned anteriorly, margin only slightly arcuate; posterior side with a narrow, submarginal fold; posterior extremity quite sharply rounded; ventral margin evenly arcuate; surface sculptured with fine concentric lines;" interior of shell not seen.[59]

A single specimen of this species was obtained from the Quillayute formation, Middle Pliocene, at the old mouth of Maxfield creek, near Quillayute, Wash.

Living: San Diego to San Francisco (Carpenter).

Pleistocene: San Diego, San Pedro, Cal. (Arnold).

Pliocene: Quillayute, Wash. (Reagan).

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[58] Arnold (in part).

[59] Arnold (in part). See above.

42. *Mactra exoleta* Gray. Plate IV, figs. 42*a*, 42*b*.

Mactra exoleta Gray, equals *Lutraria ventricosa* Gld. (*fide* Carpenter, Proc. Zoöl. Soc., 1856, p. 200). Arnold, Mem. Cal. Acad. Sci., vol. III, p. 175, pl. XIX, fig. 4, 1903.

Arnold's description : "Shell of medium size, decidedly trigonal, ventricose, thin, fragile ; umbones slightly anterior to center, elevated, not touching, turned only slightly forward ; anterior dorsal margin straight ; anterior extremity evenly rounded near base ; ventral margin evenly arcuate ; posterior dorsal margin arcuate, making an acute angle with the ventral margin ; a sharp, prominent, angular ridge runs from umbo to the posterior extremity ; surface sculptured with fine, incremental lines, which are most prominent posterior to ridge ; cartilage-pit deep ; hinge teeth lamellar, long ; ligamental groove very deep, narrow."

This species is well represented in the Quillayute formation at the mouth of Maxfield creek, opposite Quillayute, Wash.

Living : Coast of Mexico.

Pleistocene : San Diego, San Pedro, Cal. (Arnold).

Pliocene : Quillayute, Wash. (Reagan).

43. *Mactra hemphilli* Dall. Plate IV, fig. 43.

Mactra hemphilli Dall, Nautilus, vol. VII, 1894, p. 137, pl. V; Arnold, Mem. Cal. Acad. Sci., vol. III, p. 175, pl. XIX, fig. 3, 1903.

The classification of this shell is based upon its having its anterior portion hollowed in front of umbo, making the dorsal margin slightly concave, as is a leading characteristic of the species; interior of valve not seen. Shells collected are all small and immature.

Shell subtrigonal, subequilateral, convex, thin; umbones subcentral, slightly elevated, turned slightly forward; anterior end evenly rounded; posterior dorsal margin evenly arcuate; posterior end most produced near base; surface sculptured with fine incremental lines.

This is an abundant species in the Quillayute formation at the old mouth of Maxfield creek.

Pleistocene: San Pedro, Cal. (Arnold).

Pliocene: Quillayute, Wash. (Reagan).

43½. *Mactra catiliformis ?*.

Only a fragment of a shell was obtained, which is doubtfully classed as above. The posterior and anterior dorsal margins have the same declining angle from the beak as *M. catiliformis;* but the characteristic fold posteriorly is lacking.

Shell found among the other *Mactras* from the Quillayute formation.

44. *Mactra* (*Spisula*) *falcata* Gould. Plate V, fig. 44.

Mactra falcata Gld., Proc. Bost. Soc. Nat. Hist., vol. III, 1850, p. 216; Wilkes's Expl. Exped., vol XII, p. 393, fig. 506, 1852.

Standella falcata Gld., Carpenter, Brit. Assn. Rept. 1863, p. 640; Gabb, Pal. Cal. vol. II, p. 92, 1869.

Standella nasuta Gld., Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 266; Keep, West Coast Shells, p. 88, 1892.

Mactra planulata var. *falcata* Gld., Williamson, Proc. U. S. Nat. Mus., vol. XV, 1892, p. 187.

Mactra (*Spisula*) *falcata* Gould., Arnold, Mem. Cal. Acad. Sci., vol. III, pp. 176, 177, pl. XIX, fig. 1.

Arnold's description:[60] "Shell of medium size, transversely ovate-triangular, convex, rather thin; umbones about central, elevated; anterior dorsal margin nearly straight; anterior extremity rounded near the base; ventral margin subarcuate; posterior dorsal margin slightly arcuate, and in left valve forming a slight angle behind the umbo; posterior extremity not quite so sharply rounded as anterior extremity; submarginal posterior ridge rounded, not prominent; hinge as in *M. catiliformis*, except cartilage-pit less prominent; pallial sinus rather long, with rounded extremity horizontal; two broad flat ridges radiate from umbo on interior surface, forming a long, triangular depression between them."

Dimensions: Some of the older specimens are more than 100 mm. in length and 80 mm. in altitude. A medium specimen measures: Length, 82; alt., 66; diam., 32. A smaller specimen measures: Length, 12; alt., 6; diam., 6.

"Distinguishable from other species by narrower, more acutely rounded anterior end and interior radiating ridges. Resembles *M. californica*, but is distinguishable by smaller pallial sinus, lack of ridge between cartilage-pit and anterior ligamental groove, and by the interior radiating ridges and narrow anterior end."

This species is abundant in the Pliocene of Quillayute, Wash. A single specimen was also obtained from the upper series of the Oligocene-Miocene at Gettysburg, Wash.

Living: San Diego, Cal., to Kodiak, Alaska (Cooper).

Pleistocene: San Deigo (Cooper; Arnold); San Pedro, Cal. (Arnold).

Pliocene: Kirker's Pass, Contra Costa county, Eagle Prairie, Humboldt county, California (Cooper); Pliocene, Quillayute, Wash. (Reagan).

Miocene: Martinez, Sunol, Alameda county; Santiago, Los Angeles county; Foxin's, Santa Barbara county; Half Moon Bay, San Mateo county; Griswold's, San Benito county; Siebeck's, Santa Clara county, California (Cooper).

Oligocene-Miocene: Gettysburg, Wash. (Reagan).

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[60] Loc. cit.

45. *Mactra* (*Spisula*) *falcata?*. Plate V, figs. 45, *a*, *b*, *c*.

This species resembles *M. falcata*, except it is more oval in outline; inside of shell not seen. It also resembles *M. Gibbsana* but is less gibbous and has less prominent umbones.

Found with the other *Mactras* in the Quillayute formation at the old mouth of Maxfield creek.

Superfamily MYACEA; Family XXXVI MYACIDÆ; Genus *Mya*.

Shell solid, large, irregular, gaping behind; hinge edentulous; surface smooth.

46. *Mya truncata* Linne. Plate V, fig 46; times, one-half.

Mya truncata Linn. Crag. Moll., vol. II, p. 277, tab. XXVIII, fig. 1. Sears V. Wood, supplement to the Mont. Crag. Moll. Pal. Soc., vol. 27, p. 136. Billings, Geol. Can. 1863, p. 963, fig. 474. Arnold, U. S. G. S. Bull., 309, pl. 18, fig. 1.

Posterior extremity of shell (cast) broken. Shell large, rather thin; valves unequal, elongated, rounded in front and gaping behind, with a sinus trough-like area back of front margin, the one in the right valve being wider and deeper than the one in the left valve; umbones of medium size, placed anteriorly and pointed forward; surface smooth except for very fine incremental lines of growth.

Dimensions: Alt., 61.

A single specimen was obtained from the Quillayute formation.

Recent fauna: Arctic regions (Arnold).

Pleistocene, etc.: This species is found in England, in the Red Crag of Butley; in the Scrobicularia bed; in the Fluvio-Crag, at Bramerton; in the Chillesford bed, at Chillesford; at Sudborn Church Walks; in the glacially, pebbly sands at Kunten Gap, and in the middle glacial sands at Hopton, and at Bridlington (Wood).

Post-Tertiary of Canada (Logan; Billings).

Pliocene: California (Logan; Billings); Fernando formation of Elsmere Cañon, near Newhall. Los Angeles county, California (Arnold); Quillayute, Wash. (Reagan).

Class VII GASTEROPODA; Order OPISTHOBRANCHIATA.
Family XLIII SCAPHANDRIDÆ; Genus *Cylichna* Loven.

"Shell strong, cylindrical, smooth or punctate-striæ; spire minute or truncated; aperture narrow, rounded in front; columella callous, with one plait. *Cylichna arachis* Quoy. is a characteristic species." (Arnold.)

47. *Cylichna alba* Brown. Plate V, fig. 47.

Cylichna cylindracea (non-Linne), Cpr., Brit. Assn. Rept., 1863, p. 647; Cooper 7th Ann. Rept. Cal. St. Min., 1888, p. 238.

Volvaria alba Brown, Illustr. Conch. G. B., p. 3, pl. XIX, figs. 43, 44.
Cylichna alba (Brown) Loven, Ofversight K. Vet.-Akad, Forth., 1846, p. 242. Tryon, Màn. Conch., vol. XV, p. 290, pl. LX, fig. 16, 1893.[61] Arnold, Mem. Cal. Acad. Sci., vol. III, p. 192, pl. X, fig. 18.

"Shell small, cylindrical, smooth; spire truncated; aperture narrow posteriorly for about two-thirds length of shell, when the inner lip gradually retracts to the columella, forming a rounded anterior end to aperture; columella callous, with one plait."[61]

Only a broken specimen of this species was obtained from the Pliocene of the Quillayute formation.

Living: San Diego to Monterey, Cal. (Cooper).

Pleistocene: San Diego, Ventura, San Pedro (Arnold): San Diego, Santa Barbara, Cal. (Cooper).

Pliocene: San Diego well (Cooper); Quillayute, Wash. (Reagan).

Superorder STREPTONEURA; Order CTENOBRANCHIATA.
Superfamily TOXOGLOSSA; Family LII PLEUROTOMIDÆ.
Genus *Pleurotoma* Lamarck.

" Shell turriculated, fusiform, terminated anteriorly by a straight, more or less long canal; aperture oval; columellar lip smooth, straight or sinuous; outer lip somewhat sinuous, with a posterior sinus. *Pleurotoma babylonia* Lam. is a characteristic species." (Arnold).

48. *Pleurotoma perversa*. Plate V, fig. 48.

Pleurotoma perversa Gabb., Proc. Cal. Acad. Sci., vol. III, 1865, p. 183; Pal. Cal., vol. II, pp. 6, 73, pl. I, fig. 10, 1869. Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 260; equals *Surcula perversa* Gabb, Tryon, Man. Conch., vol. VI, p. 239, pl. VI, fig. 79, 1884. Arnold, Mem. Cal. Acad. Sci., vol. III, p. 200, 1903.

Shell small, sinstral, elongate, slender; whorls eight to twelve; spire high; spire in specimens at hand bent a little near apex; suture deep; body whorl, including canal, nearly half of the entire length of the shell; aperture, except lower end of canal, not seen; canal extended; surface smooth except for fine incremental, somewhat wavy lines, which are now mostly weathered away.

Dimensions: Axial length, 37; lat. of body whorl, 11; length of body whorl, 21.

Only a few specimens were obtained from the Quillayute formation.

Living: Catalina Island, Cal., to Vancouver Island (Cooper).

Pleistocene: San Pedro to Santa Barbara (Cooper); San Pedro (Arnold).

Pliocene: San Pedro, Cal.; mouth of Quinaielt river, near Grandville, Wash. (Arnold); Quillayute, Wash. (Reagan).

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[61] After Arnold, loc. cit.

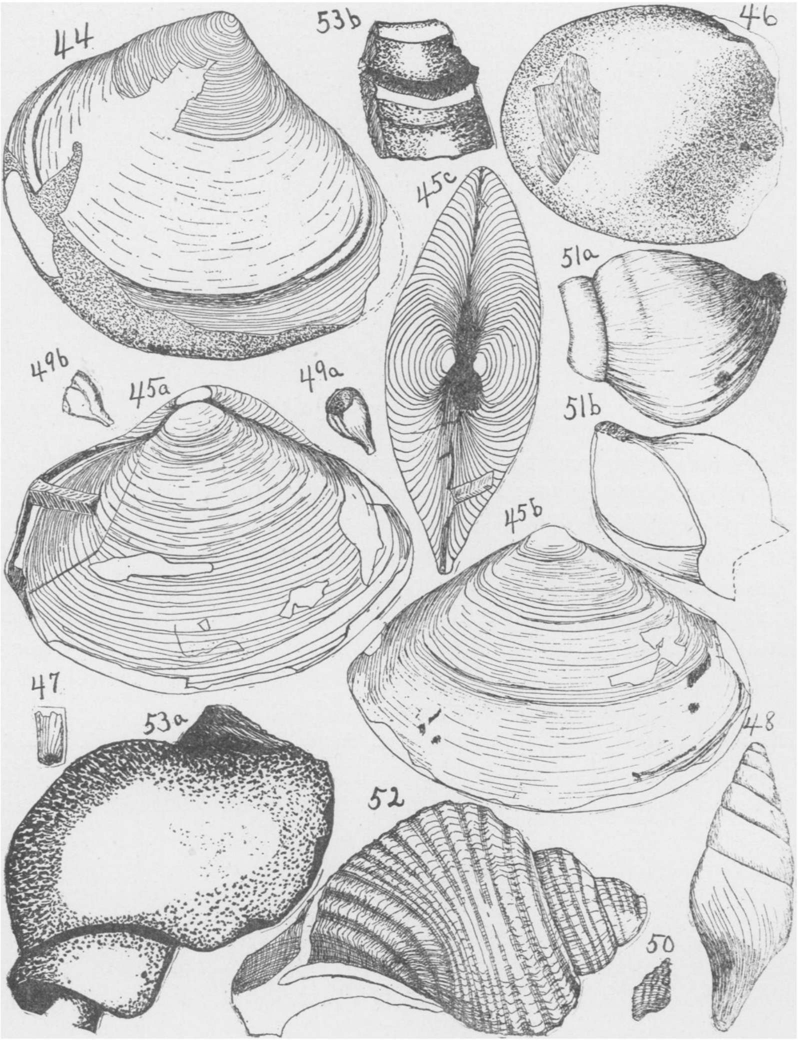

PLATE V.

Fig. 44. Mactra (Spisula) falcata Gould.
Fig. 45*a*. Mactra (Spisula) falcata?; right valve, showing umbones.
Fig. 45*b*. Left valve of same specimen.
Fig. 45*c*. Dorsal view of same specimen.
Fig. 46. Mya truncata Linne; a cast of a broken left valve; times, one-half.
Fig. 47. Cylichna alba Brown; a much broken specimen.
Fig. 48. Pleurotoma perversa Gabb.
Fig. 49*a*, 49*b*. Bela sanctæ monicæ Arnold?; specimen much broken.
Fig. 50. Bela fidicula Gould.
Fig. 51*a*. Buccinum bogachielii n. s.; a broken specimen.
Fig. 51*b*. An opposite view of 51*a*.
Fig. 52. Chrysodomus giganteus n. s.
Fig. 53*a*. Chrysodomus stantoni Arnold; a cast; times, one-half.
Fig. 53*b*. A fragment of the above specimen, showing the sloping tabular area.

Genus *Bela* Gray.

Shell oval, fusiform, thin; spire produced; canal short; sinus small, near suture; columella flattened; operculum pointed at both ends (Arnold). A characteristic species is *Pleurotoma turricula* Montf.

49. ?*Bela sanctæ monicæ* Arnold?. Plate V, figs. 49*a*, *b*.

Only a fragment of the body whorl of this shell was obtained. It had the characteristic sculpture of the above species; aperture not seen.

Fragment from the Quillayute formation.

50. *Bela fidicula* Gould. Plate V, fig. 50.

The classification of this species was made by comparing the specimen with specimens in the museum of the Leland Stanford Junior University.

Shell small, thin; spire elevated; apex subacute; whorls five (to seven), angular, forming a broad shoulder at the suture; surface ornamented with about sixteen prominent, subacute, axially arranged ribs, which extend from suture to suture, the ribs forming an angle forward across the table-like band to connect with the ridge in front of it across the suture on the next whorl above; surface also sculptured with spiral sulcations, which become spiral lines on the lower part of the body whorl to its lower extremity; a knuckle-shaped ridge begins at the notch in the lip and borders the tabular area in front of suture from lip to apex, caused by a slight elevation on each rib where it forms the angle to cross from whorl to suture; suture deeply impressed, distinct; aperture subelliptical; canal short; body whorl ventricose, without transverse sculpture on the lower part; pillar smooth internally; striate externally.

Dimensions: Axial length, 9; greatest lat., 4; height of body whorl, including canal, 6; of aperture, including canal, 6.

Distinguishable from *B. sanctœ monicœ* Arnold by smaller size and greater angulation of whorls.

The label with the specimens with which the specimen was compared stated that the shells were from the lower San Pedro series (Upper Pliocene) of California.

The specimen, the only one of the species obtained, was found among the Pliocene shells from Quillayute, Wash.

Family LVIII BUCCINIDÆ; Genus *Buccinum* Linne.

Shell inflated, smooth, or transversely ribbed; spire moderately high; aperture wide; canal short, wide open; outer lip sharp, thin; inner lip somewhat callous.

51. *Buccinum bogachielii* n. s. Plate V, figs. 51*a*, *b*.

Shell oblong-ovate, thin: whorls convex, somewhat glassy in appearance; surface ornamented with rather fine lines of growth and with two faint spiral ridges on each whorl, separated from each other by about the space of a third of the whorl in longitudinal section, the upper ridge impression on each whorl being at the beginning of the area that forms the slope to the suture; aperture ovate; canal open, short.

The specimen is from the Quillayute formation. The species is rare.

Genus *Chrysodomus* Swainson.

"Shell fusiform, ventricose; spire elevated; whorls rounded; covered with a horny epidermis; apex papillary; aperture oval; canal short; inner lip simple, smooth." (Arnold).

52. *Chrysodomus giganteus* n. s. Plate V, fig. 52; times, one-half.

Shell very large, broadly fusiform; spire elevated; whorls seven or eight, convex, sharply angulate and keeped above, forming a rimmed, spiral table, below which there is a rather wide, flattened, second table-leaf-like, declining area, bordered below by a second prominent angular ridge, followed by another depressed area; then low lands alternating with slightly depressed spaces in a revolving manner cover the body of each whorl; surface smooth except for fine, nearly oblique, incremental lines which extend over the table-areas; suture impressed; aperture elliptical-subovate; outer lip thin; inner lip incrusted; canal wide, short, curved backwards: columella twisted, smooth.

Dimensions: Axial length,?; lat. of body whorl of specimen figured, 71; of the next whorl, 38.5; height of body whorl from mouth of canal, 78; of the next whorl, 21.

Measurements of a medium-sized specimen: Lat. of body whorl, 56; of the next whorl, 33; height of body whorl from mouth of canal, 58; height of next whorl, 18; length of aperture, including canal, 53; width at widest part, 31.

This species is distinguishable from the other *Chrysodomus* species by its large size, smooth surface and double tabular area.

Specimen obtained from the Quillayute formation near the mouth of Maxfield creek, Clallam county, Washington.

53. *Chrysodomus stantoni* Arnold. Plate V, fig. 53.

Chrysodomus stantoni Arnold. Proc. U. S. Nat. Mus., 1908.

This species resembles *C. giganteus* above but differs from it in its having a more sloping primary table, nearly obsolete instead of prominent spiral sculpture, straighter walls of whorls in vertical direction, and its having a sutural canal.

Specimen from the Quillayute formation.

Unidentified specimens of this species were found in Arnold and Hamilton's collection in the museum of the Leland Stanford Junior University from Purissima Rock, Punta, Anyo Nuevo, California; also in V. W. Bradley and L. D. Frink's collection from Newyear Point (Capitola), California; and Doctor Smith has just recently advised me that Doctor Arnold has identified the species as above, from a location in the Santa Cruz quadrangle, age Middle Pliocene.

Genus *Neptunea* Bolten.

Shell elongate-ovoid, inflated, sometimes sinstral, with rather short and sometimes bent canal; aperture oval.

54. *Neptunea maxfieldii* n. s. Plate VI, fig. 54.

Shell large, robust-fusiform, thick; spire elevated, subacute; whorls five or six, convex, the convexity being more pronounced on the upper part of the whorls; suture having a notched appearance caused by the shell of the previous whorl overlapping it in saw-tooth fashion, distinct, appressed; aperture oval-elliptical to subovate; outer lip curved in and flattened at edge near suture in mature specimens; inner lip incrusted; base of aperture where it meets the canal broadly rounded; canal short, slightly curved backwards and a little to the left; columella rough, twisted; surface smooth, with the exception of faint spiral sculpture which shows principally on the lower part of the body whorl, extending on to the external part of the pillar; transverse lines are also seen on the more mature specimens, but if they were ever prominent they have been weathered away; color of shell reddish.

Dimensions of largest specimen: Axial length, 70; lat., 47; aperture, including canal, 51 x 27.

This species differs from the *Tritonidæ* in the less prominent sculpture, especially the practical absence of the transverse lines and the total absence of the nodes so characteristic of the latter; also in the upper part of all the whorls being convex. Its shape is also more that of *Neptunea* than of *Cancillaria.*

The specimens representing this species were obtained at the present mouth of Maxfield creek near Quillayute.

54½. *Neptunea* sp.

A fragment of shell from the Quillayute (Pliocene) formation proves to belong to *Neptunea;* but is too much broken to admit of specific determination.

Family LXI MURICIDÆ. Genus *Monoceros* Lamarck.

"Shell ovate; last whorl large; spire rather elevated; aperture semilunar; inner lip wide and flattened; outer lip crenated, with a prominent tooth usually at the fore part. *Monoceros lugubre* Sow. is a characteristic species" (Arnold.)

55. *Monoceros engonatum* Conrad. Plate VI, fig. 55.

Monoceros engonatum Con., Jour. Phil. Acad. Sci., vol. VII, 1837, p. 264, pl. XX, fig. 17; (equals *M. unicarinatum* Reeve, Icon. Conch., Sp. I). Cpr., Brit. Assn. Rept., 1893, p. 663. Gabb, Pal. Cal., vol. II, p. 75, 1869. Tryon, Man. Conch., vol. II, p. 195, pl. LXI, fig. 304, 1880. Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 251. Keep, West Coast Shells, p. 29, fig. 10, 1892. Williamson, Proc. U. S. Nat. Mus., vol. XV, 1892, p. 214. Arnold, Mem. Cal. Acad. Sci., vol. III, pp. 246, 247, 1903.

Arnold's description (see above): "Shell of medium size, fusiform; whorls six, angular, flattened to concave above and below; spirally sulcate, sulci with transverse lamellar striæ; suture deeply appressed, distinct; aperture subelliptical; outer lip effuse, dentate within; inner lip slightly flattened, smooth; canal deep, narrow, recurved; pillar twisted, squamose."

Dimensions (specimen obtained much broken): Axial length, more than 28; lat., 19; height of body whorl, including canal, more than 21.

A single specimen of this species was found in the Quillayute formation.

Living: San Diego to Baulinas Bay, California (Cooper).

Pleistocene: San Pedro, Ventura, San Diego, Lake Merced, San Mateo county, California (Arnold); San Pedro, San Diego (Cooper).

Pliocene: Old mouth of Maxfield creek, Quillayute, Wash. (Reagan).

Genus *Trophon* Montfort.

56. *Trophon* sp. Plate VI, fig. 56.

A fragment of a shell from the Quillayute formation proves to be of the above genus; but it is too much broken to admit of specific determination.

Subfamily PURPURINÆ; Genus *Purpura* Brugiere.

Shell oblong-oval, body whorl large, usually with transverse ribs or nodes; spire short in most species; aperture oval to ovate, large, terminating in a notch, or a very short oblique channel; columella flattened, smooth. A typical species is *Purpura persica* Linne.

57. *Purpura crispata* Chemnitz. Plate VI, fig. 57.

Purpura crispata Chemnitz, Conch. Cab., XI, pl. 187, figs. 1802 and 1803, 1795. Kuster, Conch. Cab., p. 105, pl. XIX, figs. 3 and 4, 1837. Carpenter, Brit. Assn. Rept., 1863, p. 662. Tryon, Man. Conch., vol. II, p. 175, pl. LXIII, figs. 163-166, 68, 1880. Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 261. Keep, West Coast Shells, p. 33, fig. 13, 1892.[62] Arnold, Mem. Cal. Acad. Sci., vol. III, p. 261, 1903.

The specimen here figured and described is much broken and belongs to the variable class of this species.

Shell fusiform; spire much elevated; apex subacute; whorls five to seven, angulated with two prominent spiral ridges (now much worn) on each whorl with a flattened band-like space between them; suture impressed, distinct.

Dimensions: Length without canal, 23; lat. of body whorl, 17.

Only a single specimen was obtained from the Pliocene of the Quillayute formation.

Living: Sitka to Santa Barbara (Cooper); Neah Bay, Quillayute Bay, Washington (Reagan).

Pleistocene: San Pedro, Cal. (Arnold); San Diego to Santa Barbara (Cooper).

Pliocene: Quinaielt river, near Granville (Tahola), Wash.; San Pedro, Cal. (Arnold); Seven Mile Beach, San Mateo county, California (Cooper); Quillayute, Clallam county, Washington (Reagan).

58. *Purpura lapillus* Lam. Plate VI, fig. 58.

Specimen obtained is much weathered. Shell fusiform, of medium thickness; spire elevated; apex subacute; whorls six, convex; suture impressed; aperture oval-elliptical; inner lip and columella flattened; canal short; umbilicus slightly perforate to non-perforate; surface sculpture wholly removed, except transverse growth lines.

Dimensions: Lat., 16.5; axial length, 31.

Specimen from the Quillayute formation.

Living: Quillayute Bay and Puget Sound (Reagan).

Pliocene: Quillayute, Wash. (Reagan).

59. *Purpura lapillus*, var. *quillayutea*, n. var. Plate VI, figs. 59*a*, *b*.

Shell with elevated spire, extended beak, rounded volutions; volutions numbering five or six, with strongly marked suture lines, their full, rounded, ventricose forms relieving the sutures; aperture large, semilunar in outline, terminating in a narrow canal below; outer lip thick; inner lip incrusted; canal a little recurved; surface sculpture mostly removed, except very fine oblique lines of growth parallel to the apertural margin.

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[62] After Arnold, loc. cit.

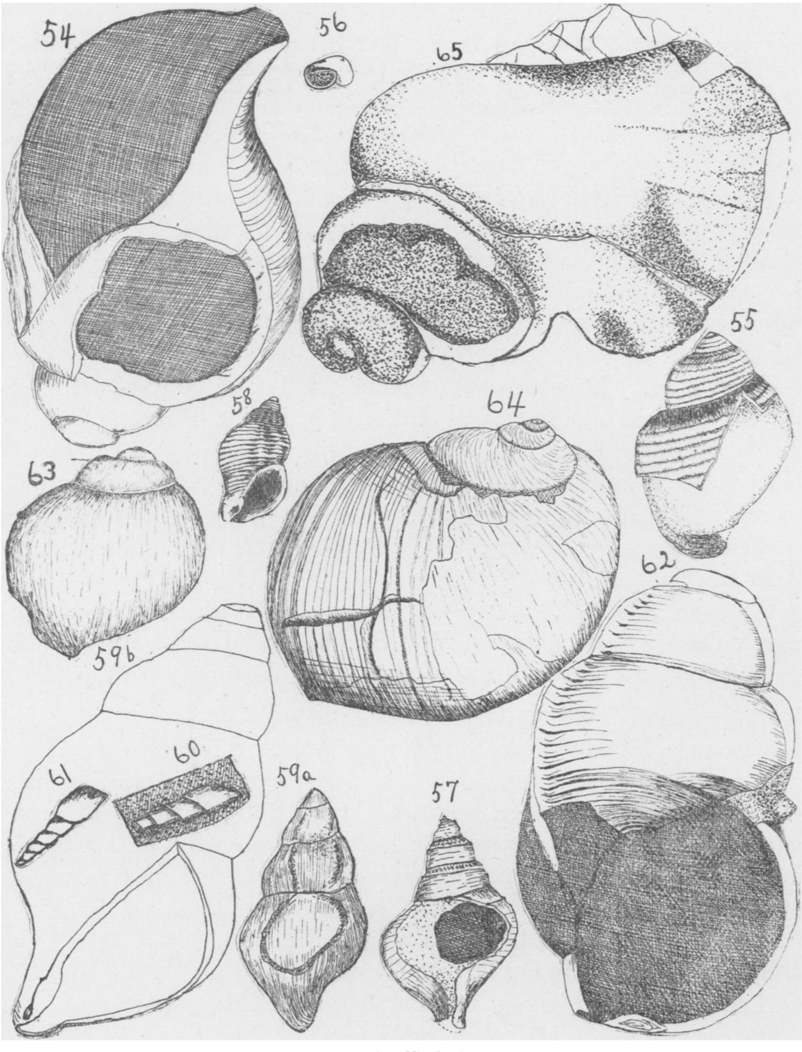

PLATE VI.

Fig. 54. Neptunea maxfieldi n. s.
Fig. 55. Monoceros engonatum Conrad.
Fig. 56. Trophon species.
Fig. 57. Purpura crispata Chemnitz.
Fig. 58. Purpura lapillus Lam.
Fig. 59*a*. Purpura lapillus, var. quillayutea, n. var.; showing rear view of a worn specimen; times, one-half.
Fig. 59*b*. Outline of same specimen, showing aperture.
Fig. 60. Eulima washingtoni n. s.; a cast.
Fig. 61. Eulima smithi n. s.; rear view of a cast.
Fig. 62. Ranella marshalli n. s.
Fig. 63. Natica (Cryptonatica) clausa Broderip & Sowerby; times, one-half.
Fig. 64. Polynices (Lunatica) lewisi Gould; times, one-half.
Fig. 65. Aporrhais (Arrhoges) quillayutensis n. s.

Dimensions: Alt. of body whorl, including canal, 40; width, 31; longest diameter of aperture, 33; transverse diameter, 18.

This variety is distinguishable from *P. lapillus* var. *saxicola*, by a less gibbous body whorl, by a smaller and more elongated aperture and by the canal being more extended and turned more backwards.

A single specimen was obtained from the Pliocene of the Quillayute formation at the old mouth of Maxfield creek, near Quillayute, Wash.

Suborder STREPTODONTA; Superfamily GYMNOGLOSSA.
Family LXIII EULIMIDÆ; Genus *Eulima* Risso.

Shell small, white, and polished; slender, elongated, with numerous level whorls; spire often curved to one side; obscurely marked on one side by a series of periodic mouths which form prominent ribs internally; apex acute; aperture oval, pointed above; outer lip thickened internally; inner lip reflected over the pillar, not umbilicated (Arnold). A characteristic species is *Eulima tortuosa* Adams.

60. *Eulimna washingtoni* n. s. Plate VI, fig. 60.

Shell small, elongated, not curved to one side, thin; spire very acute; whorls six to ten; suture distinct, impressed; aperture elongate-ovate; outer lip thin, rather arcuate.

Dimensions: Axial length of medium-sized specimen, 12; lat., 3.

This species differs from *E. micans* Carpenter in having its suture impressed.

It is a rare species in the Quillayute formation of Quillayute, Wash.

61. *Eulima smithi* n. s. Plate VI, fig. 61.

Shell resembling *Eulima washingtoni* above, but having rounder shoulders shown on the cases.

Superfamily TÆNIOGLOSSA; Family LXV TRITONIDÆ.
Genus *Ranella* Lamarck.

Shell with elongated spire, compressed, with two opposite varices which are continuous over all the whorls; aperture oval; canal short, recurved; outer lip crenulated; columella arcuated and crenulated or ridged. *Ranella spinosa* Lam. is a characteristic species.

62. *Ranella marshallii* n. s. Plate VI, fig. 62.

Shell large, broadly fusiform; spire elevated; whorls convex, each with two prominent, oppositely placed, rounded, rather reflexed varices, each forming a continuous varix from apex to base of shell; suture deeply impressed, distinct; aperture suboval; outer lip thickened, ridged without; inner lip incrusted; canal short, a little recurved; surface ornamented with very fine, revolving lines (there are no signs of there ever having been any nodes on the shell).

Dimensions: Height of shell to top of third whorl, measuring from posterior extremity of canal, 57; to the top of the second whorl, 49; to the top of the body whorl, 39; width of body whorl, including varices, 42; of first whorl of spire, 37; aperture, 34 x 25.

This species is distinguishable from *R. californica* Hds. by its absence of nodes and rugose revolving ridges and non-denticulate outer lip.

A single specimen of this species was obtained from the Quillayute formation at the mouth of Maxfield creek by Mr. Henry Marshall, who kindly presented it to the writer, and after whom it is named.

Superfamily CERITHIACEA; Family LXXVIII NATICIDÆ.
Genus *Natica* (*Adanson*) Scopoli.

"Shell subglobular; spire slightly elevated; aperture half round; spiral columellar callous entering the umbilicus. *Natica canrena* Linn. is a characteristic species."

Subgenus *Cryptonatica* Dall.

"*Natica* with smooth calcarius operculum and an umbilicus entirely and smoothly filled with callous. *Natica clausa* Broderip and Sowerby is the type."[63]

63. *Natica* (*Cryptonatica*) *clausa* Broderip and Sowerby. Plate VI, fig. 63; times, one-half.

Natica clausa Brod. and Sby., Zoöl. Jour., vol. IV, 1829, p. 360. Zoöl. Beechey's Voyage, p. 136, pl. XXXIV, fig. 3; pl. XXXVII, fig. 6, 1839. Carpenter, Brit. Assn. Rept., 1863, p. 661. Gabb, Pal. Cal., vol. II, p. 77, 1869. Tryon, Man. Conch., vol. VIII, p. 30, pl. IX, figs. 65, 67-69, 73, 1886. Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 253. Keep, West Coast Shells, p. 46, 1892. Arnold, Mem. Cal. Acad. Sci., vol. III, pp. 313 315, 1903.

Natica russa Gld., Proc. Bost. Soc. Nat. Hist., vol. VII, 1859, p. 43; Otia, p. 109, 1862. Carpenter, Brit. Assn. Rept., 1863, p. 586. Cooper, Bull. No. 4, Cal. St. Min. Bureau, part 3, 1894, p. 29.[63]

This species, as represented in the Quillayute formation, resembles *Lunatia lewisii* very much, except that the adults are much smaller and the spire more elevated in proportion to the size of the body whorl.

Shell ovate-globular; spire slightly elevated; whorls four, evenly convex to shouldered occasionally; surface ornamented by incremental lines only; suture depressed; aperture round-semioval to semilunar; inner lip callous and reflected completely over the umbilicus; outer lip sharp.

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[63] After Arnold. See above.

A numerous species in the Pliocene of the Quillayute formation at the old mouth of Maxfield creek near Quillayute, Wash.; also on the Bogachiel river in the northeast bank near Mr. Earl Wilson's place, between Forks and Quillayute.

Living: North Atlantic, Arctic Ocean, Alaska (Cooper).

Pleistocene: San Pedro, Santa Barbara, Cal. (Arnold); San Diego to Santa Barbara (Cooper); Fish Point, Lummi peninsula, Whatcom county, Washington (Reagan).

Pliocene: Santa Barbara, San Pedro, Cal.; mouth of Quinaielt river near Granville, Wash. (Arnold); Quillayute, Wash. (Reagan).

64. *Polynices* (*Lunatia*) *lewisii* Gould. Plate VI, fig. 64; times, one-half.

Natica lewisii Gld., Proc. Bost. Soc. Nat. Hist., 1847, p. 239; Wilkes's Expl. Exped., 211, pl. XV, p. 253, 1852.

Lunatia lewisii Gld., Cpr., Brit. Assn. Rept., 1863, p. 661. Gabb, Pal. Cal., vol. II, p. 77, 1869; equals *N. reiniana* Dunker and *N. algida* Gld. (See Tyron, Man. Conch., vol. VIII, p. 35, pl. XIII, figs. 11, 12; pl. IX, fig. 70, 1886.) Cooper, 7th Ann. Rept. Cal. St. Min., 1888, p. 247. Keep, West Coast Shells, p. 45, fig. 25, 1892. Dall, Trans. Wagner Inst. Sci., vol. III, part II, 1892, p. 374.

Natica (*Lunatia*) *lewisii* Gld., Williamson, Proc. U. S. Nat. Mus., vol. XV, 1892, p. 211.[64]

Polynices (*Lunatia*) *lewisii* Gould, Arnold, Mem. Cal. Acad. Sci., vol. III., pp. 315, 316, pl. X, fig. 14.

Shell very large, globose, conic; spire elevated, acute; whorls four to six, slightly convex, well rounded; body whorl large, having a long, slightly convex slope from suture to near the base, where it suddenly turns under the umbilicus; aperture ovate, broad, having a sharp lip on right margin; on the left margin the lip widens and presents a rounded edge; umbilicus moderately long, deep, nearly round; operculum thin, horny; upper whorls more concave than body whorl; whorls separated from each other by suture.

Dimensions: Adult specimens range from 70 to 100 mm. or more in axial diameter, and 60 to 80 mm. in transverse diameter. Some specimens are still larger.

Living: Discovery Harbor, Oregon, Puget Sound (Pickering); Quillayute Bay, Neah Bay, Washington (Reagan); Strait of Fuca to San Diego (Cooper); Japan (Tryon); Catalina Island (Arnold).

Pleistocene: San Pedro, Cal. (Arnold); San Nicolas Island, Santa Barbara, Cal. (Cooper).

Pliocene: Santa Barbara, Kirker's Pass, San Fernando, Cal. (Cooper); Soquel, Santa Cruz county, California (Arnold); Quillayute, Wash. (Reagan).

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[64] After Arnold. loc. cit.

Family APORRHAIDÆ; Genus *Aporrhais* Dillwyn.

Shell fusiform, turreted or oblong-ovate, with a short canal in front and a posterior canal running up the spire; outer lip of adult shells expanded and two or three digitated, digitations forming carinæ on the back of the shell.

Subgenus *Arrhoges* Gabb.

"Shell with expanded lip, merely terminating in a single posterior obtuse, lobe-like extension, and having its anterior sinus nearly or quite obsolete; posterior canal very short; anterior canal also short and obtuse."[65]

65. *Aporrhais (Aporrhoges) quillayutensis* n. s. Plate VI, fig. 65.

Volutions five or more, convex; suture distinct; body whorl large, thick; lip expanded, terminating in a single posterior large, lobe-like extension; anterior sinus nearly obsolete; posterior canal very short; anterior canal short and obtuse; surface sculpture unknown (a few fragments of the shell on the cast seem to indicate that it was smooth); inside of outer lip ridged, the ridges radiating outward.

Dimensions: Axial length, more than 60; breadth of body volution, including lip, 45; extension of lip, 21.

A single specimen was obtained from the Quillayute formation at the mouth of Maxfield creek.

This species differs from all previously known *Aporrhais* in its large size.

PLEISTOCENE STRATIGRAPHICAL SECTIONS.

1. Section taken at Port Townsend:

1.	Blue clay	10 feet +.
2.	Plaster sand	30 "
3.	Yellow and containing cobblestones	4 "
4.	Black soil	2 "

In 2 and 3 large glacial boulders are embedded.

This is the only section taken on the strait; those which follow are from the Pacific side.

2. A section in a well on the Pool place on Quillayute prairie taken from the surface down:

1.	Black loam	3 feet.
2.	Yellow and blue clay	20 "
3.	Gravel	67 "

No water was found in this well. The Quillayute prairie lies on a bench, and its greatest drawback is its lack of water.

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[65] Meek, U. S. G. S. Terr., vol. IX, p. 321.

3. A section in Mr. E. Pullen's well on Quillayute prairie:

1.	Clay and sand; sand at bottom of well; plenty of water	24 feet.

4. A section in Mr. Maxfield's well on Quillayute prairie:

1.	Loam	4 feet.
2.	Yellow clay	7 "
3.	Layers of loose gravel and of partly "cement" gravel	20 "

This well has a little water in it; but it seeps away in the gravel. The well has been abandoned.

5. A section in Mr. Peterson's well on Forks prairie:

1.	Gravel, hard-pan, clay including boulders	75 feet.

In this well, as in all the wells of Forks prairie, there is plenty of water. It is obtained from the seepage from the Calawa river. From the big bend in that river, its volume is much diminished. Its water passes beneath Forks prairie as an undercurrent and has its exit below the prairie in numerous springs, the water ultimately reaching the Bogachiel river. This water seems to follow the old channel of the Calawa prior to glacial times.

6. A section at Forks prairie on Mill creek, at the falls at Mr. Iverson's sawmill:

1.	Loam	2 feet.
2.	Yellow clay	4 "
3.	A yellow cement cobblestone stratum, causing the falls in the stream	4 "
4.	Laminated, horizontal to the cross-bedded, massive, coarse to gravelly sand containing small cobbles—stratum totally unlithified	10 feet +.

7. A generalized section from Quillayute prairie to Dickey lake:

1.	Gravelly soil	2 feet.
2.	Yellow clay. This clay digs easily as a rule. At places, however, it has a "gumbo" nature, at others a jointed structure. Where stumps had been burned it was noticed to be oxidized, being bright red in color. It seems to be a good brick and tile clay. The boulders in it attest its glacial origin. Maximum thickness	20 "
3.	Blue clay, exposed under the yellow clay stratum along the streams. This clay when wet is sticky, and gives off a bad odor. The water that seeps from it also has a bad taste. It is typical ground moraine material. In this clay, as in the yellow clay above, there are lenses of gravel. Strata of fire-clay were also seen in the bluffs occasionally	40 feet +.

Description of formation.

The Pleistocene deposits separate themselves into two groups—those exposed along the strait and those exposed along the Pacific front. Below is a description of each:

Deposits of the Strait Region.—These deposits extend from Port Townsend all the way to Neah Bay, but are exposed only in patches on the coast west of Gettysburg. The formation is of glacial origin and extends to the islands off the coast; in the formation on Protection Island many swamp stages are represented. The formation reaches its maximum thickness along the strait from Port Townsend to Gettysburg, it there being from 200 to 300 feet in thickness. Westward from Gettysburg it thins out to a mere edge. In the interior here, however, there is an abundance of evidence of glaciation at every place examined north of the northern extension of the Olympic axis; granite boulders were found 800 feet above sea-level near the top of the divide on the La Push-East Clallam wagon-road. Towards Neah Bay there are several preglacial streams filled with Pleistocene deposits that have not been recut since then; and almost all of the preglacial streams there have a wedge of Pleistocene material in the old channel on each side of the present channel. One glacial-filled channel about six miles west of the Sekiu river has a large number of granite boulders in it. The formation at its maximum-development localities has its lower member till, a stiff blue clay—probably the equivalent of Willis's Admiralty till of the Puget Sound country. The rest of the formation is roughly stratified sand and gravel.

From the material at hand, it would seem that the northern glaciers, coming against the rock walls of the Olympics in their southern advance, were compelled to dump their debris on the low lands and in the south margin of the strait depression along their front from Puget Sound west to Gettysburg, though it is probable that the deposits were augmented here by increment from the Olympic glaciers. But from Gettysburg westward, on account of a lowering of the land surface, which will be mentioned later, they passed over the western axis to the Pacific, not only not depositing much material on the strait side but in many places even scraping the rocks bare of all soil, and, passing over the divide, broke off its top, dumping the whole of its debris in the Quillayute-Ozette trough and on the ocean front beyond.

Deposits on the Pacific Front of the Peninsula.—In Pleistocene times the whole Pacific front of the peninsula was submerged or partly submerged from Waatch Strait to some distance below

Point Granville. In the north even the ridge (islands) along the southern margin of the Quillayute-Ozette syncline were submerged, and the sea claimed as her own all the present land surface to the very foot of the western extension of the Olympic axis. Marine shells are found at Beaver post-office, twenty miles inland, as well as in the stratified sands thirty-five feet above tide along the ocean front near Point of Arches. After the subsidence there came from the northward over the divide the great glacier, and, having scraped off the top of the northern country, dumped its accumulated debris in the pounding seas, extending its front outward beyond the present shore-line and the now off-shore islands, probably even as far out as the halibut banks, they likely being the final dumping-ground. And by its advancing and retreating and the working over of the material by the sea, the whole region, far beyond the present shore-line, was filled up to a level with the top of the now off-shore islands and to a height considerably above the former height of the islands and former coast-line, as all are capped with from forty to sixty feet of glacial material. Also, above the submerged area, the now eastern tributaries of the Quillayute river had their inner valleys submerged or under tidal influence far inland from the then shore-line and glacial-sheet. Consequently, they there sedimented up their channels; Pleistocene deposits were found to underlie the present bed of the Soleduck river, even as far as the Soleduck hot springs, though for many miles below that it has now removed the greater part of these deposits.

That the glacier which glaciated this region as far south as the Hoh river came from the north is attested by the fact that the upper country of the Quillayute valley shows no signs of having been glaciated; also the granite boulders seen in the deposits near Ozette lake and at many other places along the coast and in the interior region are apparently rock from the Selkirks and Mount Baker, far to the northward; there is no granite in the Olympics.

On the whole, the formation west of the Hoh river is composed mostly of sand and a poor grade of gravel, made up mostly of ground-up sandstone from the neighboring hills, with a few granite boulders scattered here and there. It reaches a thickness of 125 feet at Yellow Banks on the coast five miles east of the Ozette Indian village; but in the center of the Quillayute-Ozette it is likely much thicker. At the surface it presents the characteristic features of a glaciated region, subdued by the effects of a receding sea. Near Mr. Albright's place, near Dickey lake, overwash sand and gravel were found. McCalley lake, in section 20, having an area of about forty acres, besides a large swamp district surrounding it, seems to be a scooped-out area of glacial origin. In the vicinity of Mora and in the lower Dickey river country there are several kettles.

In the Hoh valley and from there southward the glacial debris seems to have all come from the Olympic glaciers. Its thickness and extent were not ascertained.

As a closing remark, the islands now off the Pacific coast of the peninsula were islands in pre-Pleistocene times, the same as now, with the addition of many of the present headlands. In the Pleistocene epoch they were submerged, or partly so, and then completely surrounded and covered over with debris from the glaciers and streams of the adjacent region. At the close of the epoch the country was again elevated; and the land surface was then extended farther out to sea than the present off-shore islands. Since then the sea has been continually tearing down the loose Pleistocene material and carrying it out to deeper water areas; and the resistant rock (the original islands) are made islands again as fast as the sea can remove the debris—islands the same as before, except that they now have a Pleistocene cap. And the eroding work is still going on. In front of the writer's residence the sea has encroached upon the land 300 yards in four years; and the waves now rule supreme where the Indian village stood only ten years ago. In the revolving years many of the present headlands will have all the loose material removed from around them, and they too will be islands.

Recent Deposits.—These are found in the deltas of the respective streams and in a part of the lower inner valleys of the Quillayute and Pysht rivers, and in the Waatch Strait-Suez river region west of Neah Bay. In these localities, the under rock is usually sand or gravel, or both. The surface stratum is usually a rich loam, and the areas it covers good farming districts. A part of Waatch-Suez area is semi-tide lands, and some of it is being encroached upon by beach sands, which are being continually blown inland by the prevailing southwesterly wind which sweeps the region. The construction of a dike to keep the sea out, and of a windbreak to stop the sand-dune encroachment, has been requested of the Interior Department for the benefit of the Makah Indians, in whose reservation the area lies.

As a closing remark on the structural geology of the region, quoting from Doctor Arnold:[66] "A great uplift in the Olympic

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[66] Bull. Geol. Soc. Am., vol. 17, p. 468.

Peninsula region appears to have taken place at or near the close of the Miocene epoch,[67] and still another lesser one during the late Pliocene. That orogenic movements are still taking place, or have occurred since the deposition of the Pleistocene, is evidenced by the very gently folded and tilted clays, sands and gravels in the vicinity of Port Angeles."

ECONOMIC GEOLOGY.

Sand and Gravel.

The gravel, though not a first-grade quality, is practically unlimited in quantity. The best grade is found on the strait side, but any of it is good road-building material, and is now being used for that purpose. And when the railroads once enter the region there is gravel enough in it to make the grades and keep the roads ballasted after completion.

The sand in the west end of the peninsula is a limited quantity, being confined principally to the beach districts; but fronting the strait from Gettysburg to Port Townsend it is practically inexhaustible in quantity. Where found it is a good plastering and street-paving sand.

Building Stone.

The sandstone of the Clallam formation and the sandstone of the Olympics would make good building material, but as yet there is no demand for stone in the region, and likely will not be for many years to come.

Iron Ore.

In the region back of Port Townsend, on the Puget Sound side, there are said to be mountains of low-grade iron ore ; also extinct swamps containing this metal. There were iron reduction works in this region once, but the ore there is said to be so poor in grade that the ore used was imported from the Canadian side. This iron-ore region was not visited by the writer.

Gold Placers.[68]

As yet the interior of the Olympic region has not been prospected; but many quartz veins in the mountains and in the Clallam Peak country are known to carry gold. Some in the latter region are said to carry it in paying quantities. At the present time, however, the only gold-mining carried on is that of placer mining along the Pacific beach; and it only pays in spots. The principal locations are at Shishi Beach, between Point of Arches and Portage Head; at Ozette Beach, near the village of the same name; at Yellow Banks five miles south of the Ozette Indian village; and at a point on the beach some two miles northwest of Johnson Point and six miles northwest up the coast from the mouth of the Quillayute river.

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[67] Should the Quillayute formation prove to be Upper Miocene, then there were two periods of uplift in the epoch—one at the close of the Clallam stage and the other at the close of the Quillayute.

[68] Also, see Arnold, U. S. Geol. Bull. No. 260, pp. 154-157, Gold Placers of the Coast of Washington.

In 1894 came the first gold excitement of the region, it being reported at that time that gold could be found in the beach sands almost anywhere from Gray's Harbor to Cape Flattery. A rush followed, and most of the beach was staked from Cape Flattery south nearly to the mouth of the Columbia river. Pay sand, however, has been found only at the locations above mentioned.

The gold, which is usually in small flakes, is always associated with "black" and "ruby" sands. It seems to have been concentrated at the base of the bluffs along the coast at or near bed-rock by a process of wave action, from the Pleistocene deposits capping the bluffs. In separating this metal from the sand and gravel in which it is found the sluice-box method is used wherever there is sufficient water; at other places rockers are used.

Mr. W. W. Lovelace, the owner of the Shishi placers, states that his claims have produced $15,000 in gold; and it is likely that the other claims along the beach taken together have produced a like sum.

Shishi Beach Placers.—Shishi beach extends from Point of Arches to Portage Head. This beach had furnished the richest claims on the coast up to this present year, when it was eclipsed by the placers near Johnson Point. In this district the beach claims are now mostly worked out; but recently paying placer ground has been found on the bench inland from the beach. Along this beach a low bluff of gray shale and fine gray sandstone meets the incoming tide. Superimposed upon this are yellow sands and gravels of Pleistocene age, while the beach at high-tide line is strewn with cobbles and pebbles, mostly derived from the Pleistocene deposits through the action of the encroaching sea. The rest of the beach is covered mostly with sand from one to four feet in thickness. It is in this sand and in the crevices of the underlying sandstone and shale that the gold is found. Mr. Lovelace states that he removes several inches of the bed-rock and sluices it with the sand when washing for gold on this beach.

Ozette Placers.—Along the beach at Ozette gold occurs in the sand the same as at Shishi; but on account of a lack of water but little work has ever been done. Before placer mining can be successfully carried on in this district water will have to be brought from Ozette river or lake.

Yellow Banks Placers.—Six or seven miles south of Ozette the Pleistocene deposits overlook the sea in yellowish-brown bluffs reaching a height of over 125 feet. No bed-rock is here exposed; only horizontally bedded Pleistocene sand and gravel. At the base of the bluffs are pay sands, a concentrate from material that is being continually dropped from the cliffs. Here there is an abundance of water, thus enabling the miners to use the sluice-box method of separation. Work was done in this district last year but it is now temporarily abandoned.

Johnson Point Placers.—Last winter gold was found in the beach sands near Johnson Point, also in paying quantities in the Pleistocene deposits of the bench adjacent. Since then several men have been employed at placer mining in the district; but the work is very badly hampered by flooding caused by the encroaching sea. A pan of sand here has been known to run as high as sixty cents in gold; and men have been able to clear from two to ten dollars per day. The gold consists of very fine flakes. Associated with it are magnetite, garnet, pyrite, platinum, and iridosmine.

Remarks.—The first gold excitement in the region occurred in 1894. Since then placer mining has been carried on continuously, some $30,000 having been taken from the district.

The gold is unquestionably derived from the Pleistocene deposits covering the benches adjacent to the sea, being concentrated at bed-rock at the base of the bluffs and benches by the pounding sea-waters. The gold being derived from the Pleistocene deposits, there seems to be no reason why pay gold may not be found in certain localities in these deposits as well as in the beach sands. And again, as the sea in Pleistocene times reached far inland to what it does now, it is possible that gold concentration was going on along the ocean front then as now, and that pay streaks may be found along the then ocean beach. Moreover, all the gold not brought with the glacier from the Selkirks and Mount Baker country must have been leached out of the mineral veins in the Clallam Peak district. Consequently, rich veins of gold ore may some day be discovered in that region.

Oil.

As has been casually mentioned, there are indications of oil at several places along the Pacific coast from Cape Flattery to Point Elizabeth. The conglomerate and serpentine of the supposed pre-Cretaceous series give off an odor like that of benzine, when freshly exposed, though it is quite likely that they obtain their oil from the Miocene shales adjacent by a seepage process. The supposed Cretaceous rocks in many places also give off a similar odor, and oil seepages are known to occur at several locations along the coast where these rocks are the country rocks. It is also likely that they, too, have derived their oil by seepage from the Miocene shales which they rim.

As has been seen, the Miocene series rims the Quillayute trough, and on the south side of this trough, where the older rock has been removed by the invading ocean, it forms cliffs facing the sea, being separated from the older rock by an erosive period and having its basal member a conglomerate rock of from 100 to 400 feet in thickness. The greater part of the series exposed is shale, but occasionally there are massive to thin-bedded strata of soft gray sandstone; and in the interior the whole series is capped with the sandstone of the Quillayute formation, which seems to be an equivalent of the lower Purissima of California. Wherever this Miocene formation is exposed there are oil indications, either in the occurrence of the odor of benzine or an allied product of crude oil, or in seepages. The latter are most prominently developed along the coast from the mouth of the Hoh river to the mouth of the Quillayute river. On Hoh head, near the mouth of the former stream, oil forms in pools so that one may dip it up with a cup. This oil is said to be one of the best grade oils ever found, having a forty-five per cent. paraffin base.

An oil-well was sunk on the very rim of this field to a depth of about 600 feet at a point some two miles south of the mouth of the Quillayute river in 1902, but the side pressure was so great that it caved in the pipes, and the work had to be abandoned without any oil having been obtained. A Quillayute oil company, representing people at Coalinga, Cal., is now preparing to put down a well near the old site next year. The Standard Oil people have also become interested in this field, and have now leased as much of the Forks prairie and Quillayute country as they can get at ten per cent. of the oil developed, agreeing to commence operation within three years from last summer.

It is the writer's opinion that the Standard Oil people have the best field; the seepage along the upturned broken edge of the formation along the coast is only an indication of the oil in the less-disturbed interior region.

If indications are criteria to judge by, there is an abundance of oil in the region south of the western extension of the Olympic axis.

Coal.[69]

As has been incidentally mentioned, there are indications of coal in all the sedimentary rocks west and north of the Olympics, especially in the sandstone series of the formations. As has been noticed, small veins of poor-grade coal were found exposed in the cañon walls of both the Hoko and Sekiu rivers. In the supposed Cretaceous rocks below Portage Head on the Pacific coast, small veins of black lignite were seen interbedded with the gray sandstone, the veins varying from stringers and fragments to seams several inches in thickness, the latter being exposed only at low tide. In the sandstone series of Johnson and Strawberry Points, small seams of coal are exposed, the coal seams being thicker and the coal a better grade the farther inland the exposures are found. A few miles up the Quillayute river from its mouth, a coal seam is found running in an east and west direction with nearly a vertical dip. The coal is a good grade of lignite, but the vein is less than a foot in thickness. Coal has also been found at the headwaters of the Quillayute river, at Freshwater Bay and at Clallam Bay. The last three coal areas are extensive, the coal a good quality of lignite, and in quantity sufficient to be workable.

Quillayute River Field.—A coal outcrop occurs about three miles above Salalet, or six miles from Forks, near the Bogachiel river. About fifteen years ago a railroad company, said to be The Narrow Gauge Railroad Company, spent considerable money tunneling into it. The tunnel was driven thirty feet. The coal-vein was about one foot in thickness, coal a good quality of lignite. After merely prospecting, the work was abandoned.

An analysis of coal from the headwaters of the Quillayute river, Washington, likely from the above mine, gave the following:[70]

Moisture	5.10	per cent.
Valatile combustible matter	39.15	"
Fixed carbon	47.01	"
Ash	7.77	"
Sulfur	.97	"
Total	100.00	per cent.

From indications this section will undoubtedly be a valuable coal-field when developed.

Freshwater Bay Field.—Arnold's description:[71] "The easternmost locality in (Clallam) county at which prospecting operations for coal have been carried on is in the region about Freshwater Bay, seven miles west of Port Angeles. As before mentioned, this field lies just to the south of the bay, on the northeastern portion of a broad synclinal trough. The only evidence of coal found by the writer (Doctor Arnold, also by myself) along the beach of Freshwater Bay was on the eastern side, about one and one-half miles east of Observatory Point. Here a twenty-five foot series of hard, alternating gray and brown, thin-bedded sandstone strata outcrops between the fine, gray, sandy shale, which is exposed for some distance along this part of the beach. The sandstone dips south fifty degrees west at an angle of twenty degrees, and is full of more or less altered fragments of wood, some of which are six inches in length, and most of them full of teredo borings."

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[69] Also see Arnold, Coal in Clallam county, Washington, U. S. Geol. Bull. No. 260, pp. 213-221.

[70] Loc. cit., p. 417. Also, Bethune, Geo. A., Mines and Minerals of Washington; Ann. Rept. First State Geol. Surv., pp. 15, 16, Olympia, 1891.

[71] Loc. cit.

Mr. D. J. O'Brien, former superintendent of the Port Angeles Coal and Coke Company, and now president of the Clallam Bay Coal Company, prospected this field with a diamond drill, and kindly furnished Doctor Arnold with the following drilling record from a hole in a deep gulch about one-half mile south of the eastern end of Freshwater Bay, top of hole approximately at sea-level:[72]

	Feet.	*Inches.*
Dark sandstone	39	8
Coal	0	4
Gray sandstone	24	0
Soft white sandstone	17	0
Sandstone containing oyster shells	10	0
Sandstone containing green boulders	10	0
Sandstone	40	0
Fire clay	20	0
Gray sandstone	40	0
Hard blue shale	30	0
Gray sandstone	50	0
Coal	2	2
Gray sandstone	240	0
Coal	4	8
Totals	527	10

No development work has ever been done in this field.

Clallam Bay Field.—As was stated when the geological formations of the strait region were discussed, the Clallam Bay coal-field lies in a syncline between Pillar Point and Slip Point at the entrance of Clallam Bay. This syncline has a northeasterly-southwesterly axis. At the north it is truncated by the Strait of Fuca. It extends inland for a distance of more than seven miles, but is interrupted on the east and south by sharp local faulting. In it the coal-bearing formation consists of 600 feet of coarse, thick-bedded, massive sandstone, interbedded with an occasional stratum of conglomerate. In it are interbedded several workable seams of coal.

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[72] Loc. cit., p. 418.

This coal-field was visited by Prof. J. S. Newberry, while a member of one of the Pacific railroad surveying parties. He obtained specimens of coal from a vein near Slip Point. Of this coal he gives the following analysis:[73]

Fixed carbon	46.40 per cent.
Volatile matter	50.97 "
Ash	2.63 "
Total	100.00 per cent.

In 1864 or 1865 a prospect was opened in the sea cliff two and one-half miles east of Slip Point.[73] Concerning this old mine, Mr. S. C. Gilman, in his article on the Olympic country, has this to say:

> "Between Pillar Point and Clallam bay, on the Strait of Fuca, is the abandoned Thorndike coal-mine. There are said to have been 'six leads of coal, ranging in thickness from one to three feet, dip ten degrees; distance from coal leads, 12 to 100 feet; formation, sandstone.' This is said to have been one of the best coals found in Washington. It was mined for some time, until it pinched out or was cut off by a fault, and the vein was lost and the work abandoned."[75]

Quoting from Doctor Arnold:[76] "The remains of the old pier from which the coal at the mine was loaded onto schooners were still visible in 1892, when Mr. J. S. Diller visited the locality. The location of the mine is given on the Coast and Geodetic Survey chart (No. 6300) as two and one-half miles east of Slip Point, Clallam Bay. Mr. Bailey Willis also mentions the occurrence of coal measures on the Clallam and Psyche (Pysht) rivers in his report on the coal-fields of Washington territory."[77]

The real prospecting and development work in the region dates from about 1904. At this time Mr. O'Brien, of the Port Angeles Coal and Coke Company, above mentioned, made a thorough investigation of the section of country lying between the Pysht and Clallam rivers and the strait coast, finding workable coal-seams as follows: One four miles inland and one seven miles inland, and three on the ridge facing the strait between Pillar Point and Slip Point; one seam exposed on the coast being 40 inches in thickness, another 80 feet stratigraphically below this one of 12 inches in thickness, and the other, a 22-inch seam, in the neighborhood of

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[73] Pacific Railroad Report, vol. IV, part II, p. 67.

[74] Landes, Henry, The Coal Deposits of Washington: Ann. Rept. Washington Geol. Surv., vol. I, 1901, p. 258.

[75] Nat. Geog. Mag., vol. 7, 1896, p. 139.

[76] Loc. cit., p. 417.

[77] Tenth Census, vol. 15, 1886, p. 760.

100 feet above it. And recently a slide on the strait front has exposed a six-foot vein about a half-mile from the 40-inch outcrop.

Upon finding coal in the region, Mr. O'Brien organized the Clallam Bay Coal Company, leased the land in the coal region at a very reasonable per centage, and at once began development work on the forty-inch vein. At the present time the main tunnel has been driven 600 feet, the mouth of the tunnel being on the beach, so that coal is loaded right onto ships from it. The monthly output now is about 200 tons; and work on the newly discovered six-foot vein is to be commenced at once.

The coal is a clean, hard, glossy black lignite. It breaks with a conchoidal fracture and shows extremely sharp edges. It contains small quantities of pyrite, often in veinlets; but not in quantity sufficient to damage the coal. When burned the coal leaves no clinkers. An analysis of a surface specimen of this coal by Prof. N. W. Lord, of the department of metallurgy and minerology, Ohio State University, Columbus, Ohio, gives the following:

Moisture	6.55	per cent.
Volatile combustible matter	34.25	"
Fixed carbon	47.80	"
Ash	11.40	"
Total	100.00	per cent.

Sulfur, 6.37 per cent.

Mr. M. R. Campbell, of the United States Geological Survey, who is a member of the committee in charge of the government coal-testing plant at St. Louis, has this to say regarding the Clallam Bay coal:[78]

> "I know of no use for which it may successfully compete with other coals that reach the Pacific coast; but, judging from the results which have been obtained at the government coal-testing laboratory at St. Louis during the past summer, I feel sure that the black lignite represented by this sample, although only three feet in thickness, may have considerable value. Tests made on similar lignite from the Rocky Mountain states show that it will produce gas of a higher power than that obtained from any bituminous coals of the Mississippi valley, and if gas-producers and gas-engines replace the ordinary type of engines, which seems altogether probable, it will give to this lignite a value almost, if not quite, equal to the best bituminous coal."

Recently twenty tons of this coal was sent to the government officials at Bremerton navy-yard near Seattle to have a test made of its qualities. This test, which has just been completed, shows a coal superior to any other coal produced on the Pacific coast.

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[78] See Arnold, loc. cit., p. 420.